Biomedical Engineering in Sports Science

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Hong Kong Sports Institute, 3rd June 2011
Biomedical Engineering
生物醫學工程

Sports Science
運動科學
To Improve Performance
1. Acquisition (medical devices)
2. Information Management (e-records)
3. Analysis (modelling, data mining)
4. Feedback, Correction

To Ensure Health (vs. medicine)
- Preventive
Wearable Intelligent Systems
Speedo LZR Racer technology

Elite swimmers know the difference between first and everything after comes down to the tiniest margins. The LZR Racer is the pinnacle of elite competition swimwear, featuring the latest technologies and materials to crush personal best times and finish the final lap faster.

Leading the range is the LZR Racer Elite, reengineered by Speedo Aqualabs in line with the latest FINA regulations. The Elite features a fully bonded construction for seamless movement through the water—it’s unquestionably our most advanced suit.

The LZR Racer Pro incorporates many of the outstanding technical features of the original LZR Racer, including LZR Pulse fabric to reduce muscle oscillation and skin vibration through powerful compression. It’s lightweight and water repellent, making your powerful strokes that much more effective.

With its 3D, 3-piece pattern to fit to your body shape comes the LZR Racer Comp. Fast-drying, water-repellent fabric technology means you get back in the water dry and ready to smash your personal best.

The LZR Racer range is truly the only choice for true, competitive swimmers.
The LZR Racer

- Provides extra compression in key areas to help a swimmer use less energy to swim more quickly.
- Reduces skin friction drag by covering more skin than traditional swimsuits.
- Multiple pieces of the water-resistant and extremely lightweight LZR Pulse™ fabric connect at ultrasonically welded seams and incorporate extremely low-profile zippers to keep viscous drag to a minimum.
Wearable Intelligent System

M - Miniaturised

I - Intelligent

N - Networked

D - Digitalised

S - Standardised

Artwork: Courtesy of Ms. Joey K.Y. Leung, The Chinese University of Hong Kong
Pervasive Sensing for Sports, Well-being and Healthcare

e-AR is a low-power, miniaturised ear-worn activity recognition sensor for well-being, personal training, professional sports, as well as healthcare applications. The unique design of the e-AR sensor and its signal processing power inspired by the semicircular canals of the inner ear mean that the sensor is highly sensitive, easy-to-wear, and non-intrusive. The device allows the detection of a range of indices including gait cycle, steady/unsteady locomotion, acceleration, and spinal/joint shock wave transmission.
Physiology of Auditory System

- Mechanical signal is transformed into electrical signal at the cochlear.
  - The motion of basilar membrane (BM) changes with sound pressure.
  - The inner hair cells (IHC), paired to the BM segment, transmits this mechanical signal to chemical neurotransmitter’s release, which gives rise to auditory nerve (AN) firing.

Mechano-Electro Transducing

Trains of action potential are sent to the auditory nerve fibers

Sound Wave

Central Nervous System (Auditory)
1. Anterior 1/2 circular canal
2. Ampulla (anterior canal)
3. Ampulla (horizontal canal)
4. Sacculus
5. Cochlear duct
6. Helicotrema
7. Lateral (horizontal) canal
8. Posterior canal
9. Ampulla (posterior canal)
10. Oval window
11. Round window
12. Vestibular duct (scala vestibuli)
13. Tympanic duct (scala tympani)
14. Utriculus
Sensixa e-AR

- Bio-inspired design
- Real-time gait cycle, steady/unsteady locomotion, acceleration, and spinal/joint shock wave sensing
- Ultra low power processor with integrated 2.4 GHz RF

Videos
http://vip.doc.ic.ac.uk/benlo/m775.html

G. Z. Yang et al., Imperial College, www.sensixa.com
【明報專訊】12歲運動女將一個月前突然休克到屯門醫院求醫，留院接受多項檢查，包括檢查心臟亦找不出原因，於是批准女童先出院。女童前日覆診時，院方醫生仍稱身體無恙，讵料女童回家後僅10多小時，昨晨猝死元朗寓所床上。女童雙親痛斥院方處事方法有問題：「明明說無事，為什麼會死？」

心臟科醫生何鴻光表示，一般猝死個案約70%至90%與心臟有關，10%至30%可能與腦部有關；中大內科（腦科）講座教授黃家星指出，病人失神、昏迷又蘇醒，檢查的標準做法是做心電圖、腦電圖和腦掃描等檢查找出病因（見另稿）。
12歲運動女將覆診後猝死
香港新浪網 - 2011年5月20日
（梁婉珊採） 作工於博愛醫院，將於夢中猝死的12歲女童遺體。...（林錫禮攝）【明報專訊】12歲運動女將一個月前突然休克到屯門醫院求醫，留院接受多項檢查，包括檢查 ... 12歲149磅熱衷各類運動孝順肥妹夢中猝死 - 成報
香港 - 12歲運動女健將- 通宵“煲”電視劇猝死 - 星洲日報
安慰失業父買蛋糕送母 - 新報
加拿大星島日報 - 香港商報-中國窗
共有 9 篇相關新聞 »

退休校長戰死足球場
香港新浪網 - 2011年5月14日
(綜合報道) (星洲日報報道) 何文田昨晨發生踢波猝死意外，熱愛運動的新界喇沙書院退休校長周錫輝，參加由教育局舉辦的首屆四角足球賽，至下半場他在禁區迎頂一個角球後 ... 跳頂角球倒地不起 新界喇沙前校長周錫輝踢波猝死 - 成報
新界喇沙前校長 踢波猝死球場 - 香港文匯報
退休校長周錫輝戰死足球場 - 香港商報
共有 19 篇相關新聞 »

運動猝死多關心臟問題
香港新浪網 - 2011年5月14日
【明報專訊】浸會大學體育學系副教授雷雄德表示，運動猝死與有否足夠熱身無關。他說，有運動習慣的人，運動猝死的風險較低，但不代表不會發生。據統計，每10萬至30萬人 ...
Sudden Death in the Young
What Do We Know About It and How to Prevent?

Christian van der Werf, MD; Irene M. van Langen, MD, PhD; Arthur A.M. Wilde, MD, PhD

Table 2. Clinicopathological Series on SD ≤40 Years Published Between 1990 and Mid-2009

<table>
<thead>
<tr>
<th>Study</th>
<th>Type of SD</th>
<th>Hours From Onset of Complaints</th>
<th>Study Period</th>
<th>Age, y</th>
<th>Study Population</th>
<th>n</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrado¹⁷</td>
<td>SCD/NCSD/SUD</td>
<td>&lt;1</td>
<td>1979–1999</td>
<td>12–35</td>
<td>General/athletes</td>
<td>245/51*</td>
<td>Italy</td>
</tr>
<tr>
<td>Doolan¹⁹</td>
<td>SCD/NCSD/SUD</td>
<td>&lt;24</td>
<td>1994–2002</td>
<td>&lt;35</td>
<td>General</td>
<td>425†</td>
<td>Australia</td>
</tr>
<tr>
<td>Eckart¹⁵</td>
<td>SCD/NCSD/SUD</td>
<td>&lt;1</td>
<td>1977–2001</td>
<td>17–35</td>
<td>Military</td>
<td>126</td>
<td>United States</td>
</tr>
<tr>
<td>Fabre²³</td>
<td>SCD/SUD</td>
<td>ND</td>
<td>1994–2003</td>
<td>15–35</td>
<td>General</td>
<td>223</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Giola¹⁸</td>
<td>SCD/NCSD/SUD</td>
<td>&lt;6</td>
<td>2001–2005</td>
<td>1–40</td>
<td>General</td>
<td>155</td>
<td>Italy</td>
</tr>
<tr>
<td>Meron¹³</td>
<td>SCD/NCSD/SUD</td>
<td>ND</td>
<td>1983–2000</td>
<td>&lt;35</td>
<td>Athletes</td>
<td>1041†</td>
<td>United States</td>
</tr>
<tr>
<td>Morris¹⁶</td>
<td>SCD/NCSD/SUD</td>
<td>&lt;1</td>
<td>2005</td>
<td>&lt;35</td>
<td>General</td>
<td>62§</td>
<td>Ireland</td>
</tr>
<tr>
<td>De Noronha²²</td>
<td>SCD/SUD</td>
<td>&lt;12</td>
<td>1996–2006</td>
<td>≤ 35</td>
<td>Athletes</td>
<td>89</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Quigley²²</td>
<td>SCD/SUD</td>
<td>&lt;6</td>
<td>1993–2002</td>
<td>&lt;35</td>
<td>General</td>
<td>72</td>
<td>Ireland</td>
</tr>
<tr>
<td>Shen⁹</td>
<td>SCD/NCSD/SUD</td>
<td>&lt;1</td>
<td>1960–1989</td>
<td>20–40</td>
<td>General</td>
<td>54</td>
<td>United States</td>
</tr>
<tr>
<td>Van Camp²⁶</td>
<td>SCD/NCSD/SUD</td>
<td>&lt;1</td>
<td>1983–1993</td>
<td>13–24</td>
<td>Athletes</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>Wren²⁹</td>
<td>SCD/NCSD/SUD</td>
<td>ND#</td>
<td>1985–1994</td>
<td>1–20</td>
<td>General</td>
<td>128</td>
<td>United Kingdom</td>
</tr>
</tbody>
</table>

We selected all clinicopathological studies including SD victims ages 1 to 40 years and published between 1990 and mid-2009. Only studies which extensively described the causes of SD/SCD were included, for example, a specified type of cardiomyopathy instead of “cardiomyopathy” as the final diagnosis. NCSD indicates noncardiac sudden death.

*No. of SCD/SUD cases in athletes, pulmonary thromboembolism (n=1) excluded.
†181 SD victims age <1 year excluded.
||No. of SCD/SUD cases, sickle cell trait (n=5) and stroke (n=3) excluded.
§No. of SCD/SUD cases, 16 SD victims age <1 year excluded.
||No. of SCD/SUD cases, ruptured cerebellar arteriovenous malformation (n=1) and subarachnoid hemorrhage (n=1) excluded.
#SD out of hospital, on arrival at hospital or in the emergency department.
Cardiovascular Screening in College Athletes With and Without Electrocardiography

A Cross-sectional Study

Aaron L. Baggish, MD; Adolph M. Hutter Jr., MD; Francis Wang, MD; Kibar Yared, MD; Rory B. Weiner, MD; Eli Kupperman, BA; Michael H. Picard, MD; and Malissa J. Wood, MD

Background: Although cardiovascular screening is recommended for athletes before participating in sports, the role of 12-lead electrocardiography (ECG) remains uncertain. To date, no prospective data that compare screening with and without ECG have been available.

Objective: To compare the performance of preparticipation screening limited to medical history and physical examination with a strategy that integrates these with ECG.

Design: Cross-sectional comparison of screening strategies.

Setting: University Health Services, Harvard University, Cambridge, Massachusetts.

Participants: 510 collegiate athletes who received cardiovascular screening before athletic participation.

Measurements: Each participant had routine history and examination—2.2%). Screening with history and examination alone detected abnormalities in 5 of these 11 athletes (sensitivity, 45.5% [95% CI, 16.8% to 76.2%]; specificity, 94.4% [CI, 92.0% to 96.2%]). Electrocardiography detected 5 additional participants with cardiac abnormalities (for a total of 10 of 11 participants), thereby improving the overall sensitivity of screening to 90.9% (CI, 58.7% to 99.8%). However, including ECG reduced the specificity of screening to 82.7% (CI, 79.1% to 86.0%) and was associated with a false-positive rate of 16.9% (vs. 5.5% for screening with history and examination only).

Limitation: Definitive conclusions regarding the effect of ECG inclusion on sudden death rates cannot be made.

Conclusion: Adding ECG to medical history and physical examination improves the overall sensitivity of preparticipation cardiovascular screening in athletes. However, this strategy is associated with an increased rate of false-positive results when current ECG inter-
Cardiovascular Diseases: World’s “No. 1 Killer”

Global Top Ten Causes of Death

<table>
<thead>
<tr>
<th>Rank</th>
<th>Cause</th>
<th>Deaths (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cardiovascular diseases</td>
<td>16,733,160</td>
</tr>
<tr>
<td>2</td>
<td>Cancer</td>
<td>7,120,765</td>
</tr>
<tr>
<td>3</td>
<td>Injuries</td>
<td>5,168,315</td>
</tr>
<tr>
<td>4</td>
<td>Respiratory infections</td>
<td>3,962,893</td>
</tr>
<tr>
<td>5</td>
<td>Respiratory diseases</td>
<td>3,702,199</td>
</tr>
<tr>
<td>6</td>
<td>HIV infection or AIDS</td>
<td>2,777,175</td>
</tr>
<tr>
<td>7</td>
<td>Perinatal conditions</td>
<td>2,462,124</td>
</tr>
<tr>
<td>8</td>
<td>Digestive diseases</td>
<td>1,968,397</td>
</tr>
<tr>
<td>9</td>
<td>Diarrheal diseases</td>
<td>1,797,972</td>
</tr>
<tr>
<td>10</td>
<td>Tuberculosis</td>
<td>1,566,003</td>
</tr>
<tr>
<td></td>
<td>All other noncommunicable diseases</td>
<td>4,012,061</td>
</tr>
<tr>
<td></td>
<td>All other communicable diseases</td>
<td>5,758,089</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Is there a common cause to acute myocardial infraction and stroke?
Rupture of atherosclerotic **vulnerable plaque** with **thrombosis** is the pathologic mechanism responsible for the majority of acute myocardial infarctions (AMI) and sudden coronary death (SCD).
Vulnerable Plaque: The Substrate

- The use of serological and blood markers
- Multi-modal imaging to identify the structural and functional properties of the plaque
Imaging the Vulnerable Plaque
(A) Left coronary artery angiography (B) Figure A shows the IVUS imaging of the arrow indicated area. (C) Combined backscatter (IB)-IVUS imaging, large lipid core (blue) with fibrous cap (red or white).

CT血管造影显示冠状动脉主干钙化斑块（A,箭头）和前降支近段混合斑块（A,箭）。MRI冠状动脉成像显示主干斑块所在处无管腔狭窄（B,箭头）而前降支近段斑块所在处有显著狭窄（B,箭）。

超聲成像：(A)頸動脈富含脂質斑塊 (B)頸動脈鈣化斑塊

VP Rupture – The Triggering Event

- On-body continuous measurement of the physiological triggering factors
  - Heart rate and HR variability
  - Blood pressure and BP variability
  - Pulse transit time and PTT variability

Shear stress
Vertical stress
Oscillation frequency
Blood flow

- X-Action
Home blood pressure readings are more reproducible than office readings and show better correlations with measures of target organ damage. They should become a routine component of BP measurement in the majority of patients with known or suspected hypertension.
BP, BPV: CV Mortality Indicators

French Study, 2006

19083 males (40-49 yrs. old) during 19.3 yrs.

Ohasama Study, 2000

1542 subjects (≥40 yrs. old) during 8.5 yrs

Dublin Study, 2005

5292 subjects during 8.4 yrs.

Relative Hazards of CV Mortality

Home

Clinic

Night-time

24-hour
Blood Pressure Measuring Devices

- Bulky
- Large Power Consumption
- Discomfort cuff measurement
- Cannot provide long-term, continuous readings
Validation Protocol

Collaborative with Yip & Yu, Division of Cardiology, Prince of Wales Hospital

## Consecutive Bouts of Exercise

<table>
<thead>
<tr>
<th>Condition</th>
<th>Trial No.</th>
<th>Time Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Exercise</td>
<td>1</td>
<td>5 min</td>
</tr>
<tr>
<td>Before Exercise</td>
<td>2</td>
<td>5 min</td>
</tr>
<tr>
<td>Treadmill Exercise at 9 km/h</td>
<td>--</td>
<td>3 min</td>
</tr>
<tr>
<td>After Exercise</td>
<td>3</td>
<td>5 min</td>
</tr>
<tr>
<td>Treadmill Exercise at 9 km/h</td>
<td>--</td>
<td>3 min</td>
</tr>
<tr>
<td>After Exercise</td>
<td>4</td>
<td>5 min</td>
</tr>
<tr>
<td>Treadmill Exercise at 7 km/h</td>
<td>--</td>
<td>3 min</td>
</tr>
<tr>
<td>After Exercise</td>
<td>5</td>
<td>5 min</td>
</tr>
</tbody>
</table>
Fig. 5 Comparison of LF, HF power and LF/HF ratio of RRI, SBP and PTT before and after exercise. Trial 1: resting 1 before exercise; Trial 2: resting 2 before exercise; Trial 3: after exercise 1; Trial 4: after exercise 2; Trial 5: after exercise 3. Paired Student’s t-test was employed to exam the significance of difference between trials 2~4 and trial 1 ( *P<0.05; ***P<0.01; ****P<0.001).
AR Model of CV Oscillations

\[ x(n) = \sum_{k=1}^{p} a_k x(n-k) + \varepsilon(n) \]
A prototype of the cuff-less BP watch produced by Jetfly Technology Ltd. using the PTT-based technology developed at JCBME.

Health Shirt (h-Shirt)

- Continuous measurement of multiple physiological signals & parameters, e.g. heart rate & blood pressure
- Wireless connection for remote diagnosis and display

Wearable intelligent systems have been developed for continuous estimation of multiple cardiovascular parameters, which can potentially be used for guiding exercise intensity, assessing training effects and monitoring health status of athletes.
Acknowledgement

- Hong Kong Innovation Technology Fund
- China 973 Project Fund (2010CB732606)
- Guangdong LCHT Innovation Research Team Fund

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cpoon@ee.cuhk.edu.hk
Overview of
IEEE EMBS Hong Kong Chapter

Website: www.ieee.org.hk/EMBS

E-mail: embs.hk@ieee.org
IEEE Engineering in Medicine and Biology Society is the world's largest individual-membership-based international society of biomedical engineers.

The organization's 8,200 members reside in some 70 countries around the world.

IEEE EMBS members by employment:
- 52% work in academic institutions (15% of those are in medical curricula)
- 46% work in industry (12% work specifically in the medical industry)
- 2% work in government
The IEEE-EMBS Hong Kong Chapter was founded in September 2006.

Initial no. of members: 28

Working style: Learning by Doing
We now have over 45 members.

Outstanding Chapter Award Winner

2009 EMBS Outstanding Chapter Award
Hong Kong EMBS Chapter
Committee

* We recruit committee members from different sectors – and different institutes for a balanced growth
  
  – University (60%), Industry (20%), Hospital (20%)

* Starting from this year, we also have members from University of Macau
In collaboration with local universities, HKIE, HKPC, IEEE Macau, industries, academic institutes in mainland and nearby regions, we organise
- Seminars
- Hospital visits
- Industry visits
- Student paper competitions
- Roadshow
- Technical co-sponsor / supporter of conferences
IEEE-EMBS Hong Kong Chapter
Student Paper Competition

Date: Aug 20, 2011 (Sat.)    Venue: Room 1006, HKPC Building, 78 Tat Chee Avenue, Kowloon, Hong Kong

Awards
First prize: IEEE student member fee for one year, HK$800, and a Certificate of Merit
Second prize: IEEE student member fee for one year, HK$400, and a Certificate of Merit
Third prize: IEEE student member fee for one year and a Certificate of Merit

Important Dates
Paper submission deadline: July 16, 2011
Notification of finalist: July 23, 2011
Final competition: From 9am to 1pm, August 20, 2011

Contact
For more information, please contact the executive secretariat
Prof. Carmen C.Y. Poon
Looking Ahead ...

* More benefits for members, especially students

* Collaborations with ...
  - Local BME-related organizations
  - Universities in Pearl-River Delta Region
  - Medical device industries
  - *Sports science professionals*

Your participation!
Thank You!