Remote Monitoring of the Heart Condition of Athletes by Measuring the Cardiac Action Potential Propagation Time Using a Wireless Sensor Network

S.Ananthi[1,*], V.Vignesh[1], R.Hariprakash[2], and K.Padmanabhan[3]

[1]Department of Network Systems and Information Technology, University of Madras, India.

[2]Arulmegu Meenakshi Amman College of Engineering, Kancheepuram, India

[3] AC College of Technology, Chennai, India

Received 15 January 2016; received in revised form 24 February 2016; accepted 24 March 2016

Abstract

Highly performing athletes are susceptible to cardiac damage of several kinds which may be irreversible. The monitoring of heart rate and ECG waveforms from such subjects by wireless sensor networks has been reported in health and sports care documents. However, a more decisive parameter for instant to instant changes would be the time of Cardiac Action Potential Propagation. This time, which can be between 15-20 ms would shoot suddenly in acute stress in highly performing athletes for short durations. Repeated incidents of such rising values will tend to cause irreversible damage to the heart. We developed the technique of measuring this time and reporting it through a wireless sensor network to monitoring station.

Keywords: wireless sensor networks, prophylactic athlete monitoring, ECG action potential time, ischemia

References

[1] "Athletic stress: developing coping skills through sports," http://www.bethpageswimming.com/Various%20Docs/developing_coping_skills.pdf

[2] B. J. Maron and A. Pelliccia, "The heart of trained athletes: cardiac remodelling and the risks of sports, including sudden death," Circulation, vol. 114, no. 15, pp. 1633-1644, October 2006.

[3] B. J. Maron, "Sudden death in young athletes: lessons from the hank gathers affair," New England of Medicine, vol. 329, pp. 55-57, July 1993.

[4] D. Corrado, C. Basso, A. Pavei, M. Schiavon, and G. Thiene, "Decline of sudden cardiac death in young competitive athletes after implementation of Italian pre-participation screening," Circulation, vol. 112, no. 2, pp. 604-605, 2005.

[5] B. J. Maron and D. P. Zipes, "Eligibility recommendations for competitive athletes with cardiovascular abnormalities," 36th Bethesda Conference, Journal of American College of Cardiology, vol. 45, no. 8, pp. 1318-1321, April 2005.

[6] A. Dhamdhere, H. Chen, A. Kurusingal, V. Sivaraman, and A. Burdett, "Experiments with wireless sensor networks for real-time athlete monitoring," Proc. IEEE Conference on Local Computer Networks, Oct. 2010, pp. 938-945.

[7] X. Yong, "Design of the athlete's electrocardiogram monitoring and evaluation system based on wireless sensor network," Proc. Of IEEE First International Workshop on complexity and Data mining (IWCOM2011), September 2011, pp. 60-63.

[8] M. LeGoff, "ECG using wrist-mounted EPIC sensors," Plessey Semiconductors Application Note 291465 Issue 1, pp. 1-2, http://www.plesseysemiconductors.com, 2010.

[9] S. Armstrong, "Wireless connectivity for health and sports monitoring: a review," British Journal of Sports Medicine, vol. 41, no. 5, pp. 285-289, May 2007.

*Corresponding author. E-mail address: ananthipradeep84@gmail.com

[10] R. Plonsey, "Bioelectric phenomena," McGraw Hill Inc., 1970.
[11] P. Laguna, R. Jane, S. Olmos, N. V. Thakor, H. Rix, and P. Caminal, "Adaptive estimation of QRS complex wave features of ECG signal," Medical & Biological Engineering & Computing, vol. 34, no. 1, pp. 58-68, January 1996.
[12] I. K. Daskalov and I. I. Christov, "Automatic detection of ECG T wave end," Medical & Biological Engineering & Computing, vol. 37, pp. 348-354, May 1999.
[13] K. Padmanabhan, "Circuit to explain cardiac conduction and propagation," Medical & Biological Engineering & Computing, vol. 15, no. 6, pp. 604-610, November 1977.
[14] S. Rohr, "Role of gap junctions in the propagation of cardiac action potential," Cardiovascular Research, vol. 62, pp. 309-322, May 2004.
[15] Y. Wang and Y. Rudy, "Action potential propagation in in homogeneous tissue: safety factor and ionic disturbances," Journal of Physiological Heart and Circulation, vol. 278, no. 4, pp. H1019-1029, April 2000.
[16] R. M. Karim, H. A. Khawaja, S. Naz, S. S. Merchant, I. A. Momin, I. Lalani, and Asif A. Sewani , "Q wave and non Q wave myocardial infarction - a multivariate analysis," Journal of Pakistan Medical Association, vol. 49, no. 6, pp. 149-154, June 1999.
[17] M. Goernig, B. Hoeffling, S. Lau, and H. R. Figulla, "T-vector and loop characteristics improve detection of myocardial injury after infarction," Medical & Biological Engineering & Computing, vol. 35, pp. 381-386, June 2015.
[18] K. Padmanabhan and S. Ananthi, "Analysis of fibrillation and defibrillation to develop minimal energy defibrillator," Journal of Institution Engineers (India), vol. 89, no. 5, pp. 3-10, May 2008.
[19] M. B. Waxman, N. D. Berman, and E. Downer, "A method for on-line automatic beat to beat digital display of cardiac action potential duration," Medical & Biological Engineering & Computing, vol. 14, no. 2, pp. 136-140, March 1976.
[20] R. M. McGillvray and R. W. Wald, "Measurement of the maximum rate of rise of the cardiac AP," Medical & Biological Engineering & Computing, vol. 22, no. 3, pp. 275-276, May 1984.
[21] M. Kohvakka, "Wireless sensor prototype platform," Proc. of the Industrial Electronics Society (IECON '03), The 29th Annual Conference of the IEEE, November 2003, vol. 2, pp. 1499-1504.