



SURVEY ON IMPLANTATION OF KNEE REPLACEMENT

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ABSTRACT- Add up to knee substitution is an operation as often as possible required by haemophiliacs patients, which incredibly enhances their personal satisfaction. This operation, be that as it may, conveys a higher danger of draining and disease for haemophiliacs than it improves the situation osteoarthritis sufferers. It is prudent to embed prosthetic segments utilizing anti-toxin stacked bond. It is fundamental to keep up a level of 100% of the trade thickening variable for 2 weeks. Haematological treatment must be set up, contingent upon the patient's factor levels and other pharmacokinetic parameters, for example, recuperation and half-life, ideal dosages and treatment time. It is desirable over utilize general anaesthesia because of the danger of spinal dying. The life expectancy of aggregate knee substitution in haemophilic patients is shorter than in patients with osteoarthritis in view of the expanded danger of disease. The biomechanics of the knee joint give a vital premise to the method of reasoning in the plan and determination of suitable aggregate knee arthroplasty. This article looks at knee biomechanics as far as patient capacity, prosthesis outline, cruciate tendon maintenance, arrangement, and obsession of the tibia part. While plan and surgical system for add up to knee substitution advance, a superior comprehension of the qualities of joint stacking, push circulation, and the biologic reaction of issue that remains to be worked out will give the possibility to enhance both capacity and embed life span.

Keywords-bio impedance, loso cross-validation, ebi measurements.

INTRODUCTION

Human stance and development investigation is basic for an extensive variety of utilizations and orders, for example, physical and neuro-recovery, sports pharmaceutical, human execution evaluation and virtual preparing. Albeit standard movement examination instruments are broadly utilized as a part of these fields, the advancement and approval of walking and unpretentious detecting frameworks, which give a solid estimation of human movement and action in out-of-lab day by day life, are as yet open issues in the present writing. The advancement and approval of wearable innovations went for enabling doctors and specialists to remotely manage and mentor the patients amid their restoration practice in their recuperation stage are a portion of the present difficulties. Innovative headways in knee arthroplasty have made it common around the globe, with over a large portion of a million essential methods performed in England and Wales alone amid the most recent decade. It is a complex surgical methodology which requires legitimate arrangement of the new and existing articular surfaces, in blend with exact re-situating of the related tissues. The quantity of aggregate knee substitution (TKR) surgeries is continually ascending because of expanded populace and future rates; and also a general

decrease in the age at the season of beginning TKR. Therefore, broad research is being completed on the best way to enhance the survival rates and delay the life expectancy of the embed. Furthermore, early identification of high wear rates takes into account expectant treatment which could in the end counteract untimely embed disappointment. The most reasonable justification of untimely embed disappointment is aseptic extricating, which is a serious physiological reaction to remote flotsam and jetsam in the joint. This trash is created from grating wear in the ultra-high sub-atomic weight polyethylene (UHMWPE) of the tibia embed, because of malpositioning of the articular surfaces and the high powers acting in the joint. In this way compelling checking of the dynamic worries inside the UHMWPE embed can give a clearer view of knee biomechanics, and give constant perception on the state of the knee embed. Albeit past endeavours have been made at planning implantable checking frameworks, many are just usable amid the surgical procedure or expect adjustments to existing insert engineering. In this examination, indistinct magnetostrictive strips were incorporated into UHMWPE as sensors for measuring the compressive burdens following up on the embed. The crucial outline and rule of operation are exhibited close by comes about acquired from starting tests did.

LITERATURE SURVEY

Josep Sol'a, Olivier Ch'etelat, Claudio Sartori, Yves Allemann, and Stefano F. Rimoldi in the year 2011 introduced about a Pulse-wave speed (PWV) is considered as the gold standard strategy to survey blood vessel firmness, an autonomous indicator of cardiovascular dreariness and mortality. Current accessible gadgets that measure PWV should be worked by talented restorative staff, subsequently, decreasing the potential utilization of PWV in the wandering setting. These days procedures that permit non-invasive appraisal of PWV fall into two principle classes. These gadgets recognize the landing time of a weight beat that spreads through the blood vessel tree, and compute the postponement in beat entry time (PAT) between the proximal and distal sensors. By around measuring the separation through which the beat wave has proliferated, one gauges a heartbeat spread speed esteem. Expansive clinical investigations bolster the unwavering quality and clinical legitimacy of this system. A novel chest sensor giving appraisals of the travel time of weight beat waves to proliferate from the aortic valve to the sternum vascular bed has been displayed. In the approval ponder, the chest PTT was exhibited to emphatically correspond with the CF PWV estimations. ICG flag is thought to be a decent gauge of the opening of the aortic valve, and is alluded to as B-point. This technique permits finding B-focuses notwithstanding when no expressions are available in the ICG signals. The third subsidiary of

ICG contains a few misdirecting neighbourhood maxima, and this approach is difficult to be actualized in an unsupervised way[1].

Sinan Hersek, Hakan Töreyn and Omer T. Inan in the year 2016 introduced about a knee wounds are among the most widely recognized explanations behind specialist's visits. Roughly 10 million patient visits are made every year in the United States for regular knee in-juries, for example, sprains and tendon tears. The frequency rate per 1,000 people for knee wounds is 2.29, with the most widely recognized conclusions being strains and sprains. Standard examinations don't yield any quantitative input to the doctor or patient in regards to, for instance, the swelling, scope of movement, or basic honesty of the joint. Examination strategies in light of demonstrative imaging do give quantitative measurements of joint wellbeing. One innovation that has been examined for neighborhood joint wellbeing appraisal as of late is electrical bio impedance. EBI has been exhibited in past examinations as a conceivable methods for assessing knee osteoarthritis, edema (swelling) identified with bring down appendage muscle wounds. This future wearable framework in view of the building establishment displayed in this paper can empower high determination, quantitative evaluation of both the basic and hemodynamic attributes of the knee joint longitudinally out of the blue, preparing to better understanding joint recuperation physiology, and planning shut circle customized treatments to quicken the recuperation process. The consolidated utilization of elite simple the front-stop gadgets and advanced programmability utilizing a microcontroller permit fantastic static (step by step fluctuating thru the span of hours to days) and dynamic (quickly differing on the request of mill-seconds) impedance estimations on a level that serves a framework stage biomedical affirmation of-concept. yet, they are much less generally utilized in light of the fact that they may be costly and tedious. past the ability, for instance, inside the home or with wearable improvements, there are not any realistic arrangements handy for giving inside and out, quantitative joint wellness appraisal[2].

Yu Mike Chi, Tzyy-Ping Jung, Gert Cauwenberghs in the year 2010 exhibited about a biopotential chronicles as electrocardiograms (ECG), electroencephalograms (EEG), electrooculograms (EOG) and electromyograms (EMG) are key and imperative instruments for both therapeutic and research utilize. The fundamental standards behind gel-less terminals are likewise outstanding. In spite of many years of research in elective biopotential sensor advancements for ECG and EEG applications. This paper plans to fundamentally address the most recent advancements in dry and noncontact terminals representing both of these contemplations. FET-input speaker arranged in solidarity pick up will be more than adequate to support signals from for all intents and purposes any anode. Accomplishing an adequately high info impedance isn't an issue for the lion's share of cases. Info balances are dangerous, yet DC-coupled instrumentation with low picks up (0 dB) and high-determination ADCs (24-bit) can endure extensive cathode counterbalances. Settling the troubles with movement antiquities remains the unsolved test in portable, wearable ECG/EEG sensor systems. Unlike circuit portrayal which includes standard, effortlessly reenacted and promptly measured parameters like commotion, pick up and control utilization, movement curios are not well characterized and subject to human fluctuation. The fundamental standards behind gelless cathodes are likewise well known. Despite many years of research in elective bio potential sensor advances for ECG and EEG applications. Second, since anodes interface to the skin either in contact or closeness to the body, the particular cathode should likewise be assessed for solace and utility at the framework level. In one boss preferred standpoint of the standard clinical wet terminal is the way that it clings extremely well to skin. Again the absence of standard estimation techniques joined with human inconstancy makes a target correlation rare and troublesome[3].

Pranali C. Choudhari¹, Dr. M. S. Panse² in the year 2014 exhibited about an Impedance cardiograph has turned into an

equivalent word for backhanded appraisal of checking the stroke volume, cardiovascular yield and other hemodynamic parameters by observing the blood volume changes of the body as far as changes in the electrical impedance of a body portion. An established measurable strategy for benchmark cancelation, can be utilized to stifle the ancient rarities, however it likewise curbs the beat-to-beat varieties and has a tendency to limit the top in the ICG. A straight time-fluctuating separating approach is attempted to stifle the benchmark float in the ECG flag. Beat normal is subtracted from the flag and after that obliterated. Low-pass separating is connected to gauge the benchmark meander and is introduced. At that point it is subtracted from the first flag. The bio impedance flag is of awesome significance in figuring the heart yield, stroke volume and other cardiovascular parameters. It is of most extreme significance to accurately find the trademark focuses on the flag, in this way maintaining a strategic distance from blunder estimation of the parameters for determination. Different standard meander evacuation calculations have been executed in the writing, however the real test in this usage was the phantom cover between the commotion and the flag and practically identical amplitudes. Since the quantity of levels of disintegration are figured utilizing the vitality of the flag itself, each flag gets an alternate treatment for expulsion of the benchmark float. Eight to ten levels of dyadic wavelet parcel decay were required in each of the subject for effectively evaluating the gauge float. This is a nonlinear technique, and its execution depends on estimation of reference focuses in the PR interims. Technique looks very easy to execute, the quantity of coefficients utilized the FIR structure is too high and results in long drive responses. Most of the gauge meander evacuation calculations in the writing have been actualized for denoising the ECG flag and less work has been done in bioimpedance signals. This is a nonlinear approach so it is perplexing and exceedingly ward to pulsate rate computations and turns out to be less exact in low heart rates. Direct sifting is another strategy connected to benchmark meander problem. The primary detriment of this technique is assessing reference indicates that may not have a place pattern[4].

Jüri Vedruin the year 2010 displayed about an electrical impedance strategies depend on estimation of the electrical impedance (i.e., the modulus of the full complex protection) of the human body or its parts at sub-high recurrence (20...200 kHz). It has been discovered that the impedance of body beats in synchronism with the heart. This throb is the root of impedance plethysmogram. Abundancy of the impedance plethysmogram involves around 1/1000 ... 1/100 of the mean estimation of the watched impedance. A few techniques have been produced on the premise of depicted marvel for estimation of the volume stream of blood in various organs or parts of the body. The strategy has valuable preferences (does not require assurance of ρ , L), it is by all accounts a stage towards the completely backward estimation of SV on the premise of just anthropometrical information. Consequently we could get just mean factual gauges yet not individual measured esteems for the solid individual with his/her conceivable pathology. In that same year, The Kubicek strategy is experimental and the figuring recipe does not clearly contain any adjustment coefficient just because of appropriate decision of the area of the lower potential cathode[5].

M. c. jones, j. s. marron, and s. j. sheather in the year 1996 exhibited about a Smoothing techniques give an intense procedure to picking up bits of knowledge into information. Be that as it may, viable utilization of these strategies requires decision of a smoothing parameter. At the point when deficient smoothing is done, the subsequent thickness or relapse assess is too harsh and contains spurious highlights that are ancient rarities of the inspecting procedure. This article is expected to give brisk access to the primary thoughts behind" second era techniques. "A pick up for lucidity, in light of the fact that there are numerous varieties that can darken the fundamental thoughts, we concentrate just on two speak to at Give

technique s:a "understand the-condition module" strategy a nda4"smoothed bootstrap. Our outcomes is that a portion of the objective densities are "anything but difficult to evaluate," implying that enough data is available in the information to recuperate a large portion of the highlights of the objective Interactive visual decision of the smoothing parameter is a capable approach to break down information. This is valuable in sparing the season of specialists through giving a sensible beginning stage, yet it ends up plainly basic while smoothing I s utilized by non-master This shows while the non-asymptotic objective understood in the smoothed bootstrap approach all the more engaging, better down to earth execution appears to originate from endeavouring to appraise the amise than the mise[6].

Lavdaniti M in the year 2008 introduced about the hemodynamic status observing of high-hazard surgical patients and fundamentally sick patients in Intensive Care Units is one of the principle destinations of their remedial administration. Heart yield is a standout amongst the most essential parameters for cardiovascular capacity checking, giving a gauge of entire body perfusion oxygen conveyance and taking into consideration a comprehension of the reasons for hypertension. The intrusive techniques are the Fick strategy and the rmodilution, though the non-obtrusive strategies are oesophageal Doppler, Tran's oesophageal echocardiography, and lithium weakening, and heartbeat form, incomplete CO2 rebreathing and thoracic electrical bio impedance. Cardiovascular output is the volume of blood pumped by the heart every moment and is the result of the heart rate and stroke volume. The stroke volume of the ventricle is controlled by the communications between its preload, contractility and after load. Moreover, attendants can analyse the heart yield measured by different strategies, for example, the rmodilution and thoracic electrical biompedance, or fractional CO2 rebreathing and thoracic electrical biompedance. The perfect framework for heart yield observing would be non-obtrusive, simple to utilize, precise, dependable, reliable and good in patients .The Fick technique has impediments which are set apart in patients with lung irregularities. It is exorbitant and may prompt entanglements. Likewise, it is viewed as the most precise technique accessible to assess patients with low heart yield. They are not planned to supplant the pneumonic conduit catheter, which remains very interesting in giving weight (right blood vessel, aspiratory wedge weight) and also venous oxygen immersion, notwithstanding heart yield[7].

Anja Walter-Kroker, Axel Kroker, Muriel Mattiucci-Guehlke and Thomas Glaab, in the year 2011 exhibited about lost body weight and consumption of fat free bulk are normal and difficult issues in patients with unending obstructive pneumonic illness (COPD) regardless of the level of wind current confinement. Surrogate measures, for example, the outstanding Body Mass Index (BMI) give no sign of body piece, bulk or nourishing state. These patients are typically not identified by subjective worldwide evaluation of dietary status. On account of COPD, it has been perceived that it is low sans fat mass (FFM) additionally separated into body cell mass (BCM) and additional cell mass (ECM) instead of low BMI that ought to be considered as a basic parameter of sickness seriousness and guess BIA is a basic, economical, snappy and non-intrusive method for surveying body structure and its progressions after some time. BIA is to a great extent utilized as a part of clinical trial settings and there is an entire arrangement of writing on the hypothesis and approach of a few diverse BIA techniques.TBW is extraordinarily lessened and BCM additionally is diminished. With the lessened BCM it should be remembered here that BCM is reliant on the patient's liquid status[8].

A. A.Danilov,v. k. kramarenko, d. v. nikolaev, and a. s. yurova, in the year 2013 displayed about a bioelectrical impedance examination (BIA) is normally utilized for body piece and stomach adiposity appraisal. BIA is likewise utilized as a part of checking body liquid redistribution under different physiological and neurotic conditions. The computational investigation of the current estimation plans is

basic for precise information understanding and the advancement of new cathode plans. One of the methodologies depends on the count of the relative commitment of the tissues and organs to the aftereffect of bioimpedance estimations of the specific body portion. A precise 3D show requires high determination understanding information like CT or MRI for the entire body, which as a rule isn't accessible. However the anthropometrical estimations of the body are effectively available, and now and again we may have nearby CT/MRI pictures with persistent particular highlights. Customized demonstrate adjustment, including anthropometrical scaling, control focuses mapping and geometrical alteration of the body furthest points position. We have thought about our past aftereffects of segmental bioimpedance examination utilizing the VHP man model to the changed model with an amended position of the arms. The proposed adjustment strategies might be utilized for customized BIA, and also for BIA of a body with various places of the limits. Demonstrating estimation procedures including the particular position of the patient, as it might impact the consequences of the estimations. A precise 3D show requires high determination tolerant information like CT or MRI for the entire body, which much of the time isn't accessible[9].

H. WI, T. E. Kim, T. I. Gracious, and E. J. Charm in the year 2012 exhibited about an EIT can deliver practical pictures of conductivity varieties related with physiological occasions, for example, cardiovascular and respiratory cycle's .After the main advancement of EIT was displayed by Brown and Seagar, EIT has created and clinical examinations have been performed, however regardless it needs the leap forward to apply EIT in facility. We have to expand its yield impedance over 1 M ω to get 0.1% exactness to a most extreme working recurrence. Since we infuse streams with variable amplitudes from numerous present sources, we should deliberately align any little changes in their present amplitudes and stages. Another multi-recurrence parallel EIT framework, the KHU Mark2.5 for spectroscopic conductivity imaging of the creature subject and assessed its execution. All IMMs are worked synchronously and freely for adaptable arrangement and expanding the securing speed. The following rendition of our EIT framework will procure biosignal, for example, ECG or EEG together with EIT information. Incorporated EIT framework can indicate better translation for physiological variety and give a chance to defeat clinical utilizations for EIT. A biosignal-gated imaging is valuable to decide the connection between the recreated impedance pictures and heart movement or breath. It will enable us to catch quick cardiovascular occasions and may likewise enhance the flag to commotion proportion (SNR) utilizing signal averaging methods.Without utilizing biosignal gated imaging, conductivity changes from heart work can't be demonstrated in light of the fact that it is littler than one of breath[10].

APPLICATIONS

By using excessive performance analog front-end electronics and virtual programmability the usage of a microcontroller permit high pleasant static (slowly various over the course of hours to days) and dynamic (hastily varying on the order of milli-seconds) impedance measurements on a platform that serves a machine-level biomedical proof-of-concept.but those are less typically used due to the fact they're highly-priced and time eating. beyond the clinic, together with inside the domestic or with wearable technology, there aren't any feasible answers to be had for imparting in-depth, quantitative joint fitness assessment.The primary standards behind gelless electrodes are also widely known.despite decades of studies in opportunity biopotential sensor technology for ECG and EEG packages.2d, because electrodes interface to the pores and skin either in touch or close proximity to the frame, the precise electrode need to also be evaluated for consolation and application on the system stage.One predominant benefit of the standard medical moist electrode is the reality that it adheres very well to skin.the dearth of widespread dimension strategies mixed with human variability makes an goal

evaluation scarce and tough. Most of the baseline wander elimination algorithms within the literature were implemented for denoising the ECG sign and there's very much less paintings has been performed in bioimpedance signals. That is a nonlinear method so it's far complex and exceedingly dependent to beat charge calculations and becomes much less accurate in low heart charges. Linear filtering is every other technique carried out to baseline wander hassle. The principle drawback of this approach is estimating reference factors that may not belong to baseline. Measurements of the electric impedance commonly deliver facts at the composition of the analyzed quantity, based totally on the variability of dielectric homes and the frequency dependence of these homes is used to growth the accuracy of the approach. Whilst uncovered to low frequency electric challenge, human tissues behave much like conductive materials. The Kubicek method is empirical and the calculation formula does no longer certainly contain any calibration coefficient best because of suitable choice of the area of the decrease ability electrode. Interactive visual desire of the smoothing parameter is a totally effective manner to analyze statistics. That is beneficial in saving the time of professionals via offering a sensible starting point, but it turns into vital when smoothing is used by non professional. The Fick technique has boundaries which are marked in patients with lung abnormalities. It is steeply-priced and can result in complications. Also, it's far taken into consideration the maximum correct technique available to assess patients. They're now not intended to update the pulmonary artery catheter, which remains pretty particular in supplying strain. BIA (Bio-Impedance evaluation) is a easy, cheaper, short and non-invasive method for assessing body composition and its modifications over time. BIA is largely used in clinical trial settings and there may be a whole series of literature on the principle and methodology of several exceptional BIA strategies. Modeling size strategies involving the particular role of the patient, as it may have an impact on the effects of the measurements.

CONCLUSION

All in all, this exploration accentuated the significance of reestablishing a patient's unique articulating surfaces when their knee joints are influenced by damage or malady. A strategy for planning a patient-particular UKR (Unicompartmental Knee replacement) was given and tried respect to contact stresses and kinematics. It was demonstrated that patient-particular inserts can have qualities practically identical to, and in specific cases better, than traditional prostheses. The one of a kind outline system displayed here presents a noteworthy progression in knee substitution innovation, with the possibility to drastically enhance clinical results of knee substitution surgery.

REFERENCES

- [1] J. Sola et al, "Chest Pulse-Wave Velocity: A Novel Approach to Assess Arterial Stiffness," *IEEE Transactions on Biomedical Engineering*, vol. 58, no. 1, pp. 215-223, 2011.
- [2] S. Hersek, H. Toreyin, and O. T. Inan, "A Robust System for Longitudinal Knee Joint Edema and Blood Flow Assessment Based on Vector Bioimpedance Measurements," *IEEE Transactions on Biomedical Circuits and Systems*, vol. 10, no. 3, pp. 545-555, 2016.
- [3] Y. M. Chi, T.-P. Jung, and G. Cauwenberghs, "Dry-contact and noncontact biopotential electrodes: methodological review," *Biomedical Engineering, IEEE Reviews in*, vol. 3, pp. 106-119, 2010.
- [4] P. C. Choudhari, and M. Panse, "Artifact Removal from the Radial Bioimpedance Signal using Adaptive Wavelet Packet Transform," *International Journal of Computational Engineering Research (IJCER)* vol. 4, no. 7, pp. 2250-3005, July 2014.
- [5] W. G. Kubicek, R. P. Patterson, and D. A. Witsoe, "Impedance Cardiography as a Noninvasive Method of Monitoring Cardiac Function and Other Parameters of the Cardiovascular System," *Journal of Physics: Conference Series*, vol. 224, no. 1, 2010.
- [6] M. C. Jones, J. S. Marron, and S. J. Sheather, "A brief survey of bandwidth selection for density estimation," *Journal of the American Statistical Association*, vol. 91, no. 433, pp. 401-407, 1996.
- [7] M. Lavdaniti, "Invasive and non-invasive methods for measurement of cardiac output", *International Journal of Caring Sciences*, vol 1(3), 112-117, 2009.
- [8] Anja Walter-Kroker, Axel Kroker, Muriel Mattiucci-Guehlke and Thomas Glaab, "A practical guide to bioelectrical impedance analysis using the example of chronic obstructive pulmonary disease", vol. no 1475-289-10-35, April, 2011.
- [9] Danilov A.A. Kramarenko V.K. Nikolaev D.V. Yurova A.S., "Personalized Model Adaptation for Bioimpedance Measurements Optimization", *Russ. J. Numer. Anal. Math. Model.*, vol. no 459-470, 2013.
- [10] H. WI, T. E. Kim, T. I. Gracious, and E. J. Charm, "Expandable Multi-frequency EIT System for Clinical Applications", *Department of bio-medical Engineering*, vol. 28, no. 07, 2012.
- [11] D. S. Miles et al, "Estimation of cardiac output by electrical impedance during arm exercise in women," *Journal of Applied Physiology*, vol. 51, no. 6, pp. 1488-1492, 1981.
- [12] A. Piccoli et al, "A new method for monitoring body fluid variation by bioimpedance analysis: The RXc graph," *Kidney International*, vol. 46, no. 2, pp. 534-539, 1994/08/01, 1994.
- [13] U. G. Kyle et al, "Bioelectrical impedance analysis—part I: review of principles and methods," *Clinical Nutrition*, vol. 23, no. 5, pp. 1226- 1243, 10//, 2004.
- [14] G. Medrano, S. Leonhardt, and P. Zhang, "Modeling the influence of Body position in bioimpedance measurements." pp. 3934-3937.
- [15] H. Lukaski, and M. Moore, "Bioelectrical Impedance Assessment Of Wound Healing," *J Diabetes Sci Technol*, vol. 6, no. 1, pp. 209-212, 2012.
- [16] L. Nescolarde et al, "Localized bioimpedance to assess muscle injury," *Physiological Measurement*, vol. 34, no. 2, pp. 237, 2013.
- [17] L. Nescolarde et al, "Effects of muscle injury severity on localized bioimpedance measurements," *Physiological measurement*, vol. 36, no. 1, pp. 27, 2014.
- [18] C. Pichonnaz et al, "Bioimpedance spectroscopy for swelling evaluation following total knee arthroplasty: a validation study," *BMC Musculoskeletal Disorders*, vol. 16, no. 1, pp. 1-8, 2015.
- [19] L. Fabrizi et al, "Analysis of resting noise characteristics of three EIT systems in order to compare suitability for time difference imaging with scalp electrodes during epileptic seizures," *Physiological measurement*, vol. 28, no. 7, pp. S217, 2007.
- [20] G. Medrano, S. Leonhardt, and P. Zhang, "Modeling the influence of body position in bioimpedance measurements." pp. 3934-3937.

- [21] J. Friedman, T. Hastie, and R. Tibshirani, *The elements of statistical learning*, pp. 417-426: Springer series in statistics Springer, Berlin, 2001.
- [22] S. Raschka, *Python Machine Learning*, pp. 210-213: Packt Publishing Ltd, 2015.
- [23] M. N. Sawka, "Body Fluid Responses and Hypohydration During Exercise-Heat Stress," *Human Performance Physiology and Environmental Medicine at Terrestrial Extremes*, K. B. Pandolf, M. N. Sawka and R. R. Gonzalez, eds., pp. 236-240, Indianapolis, IN: Brown & Benchmark Press, 1988.
- [24] E. B. Neves et al, "Knee bioelectric impedance assessment in healthy/with osteoarthritis subjects," *Physiological measurement*, vol. 31, no. 2, pp. 207, 2009.
- [25] H. Hsu, and P. A. Lachenbruch, "Paired t test," *Wiley Encyclopedia of Clinical Trials*, 2008.
- [26] Y. M. Chi, T.-P. Jung, and G. Cauwenberghs, "Dry-contact and noncontact biopotential electrodes: methodological review," *Biomedical Engineering, IEEE Reviews in*, vol. 3, pp. 106-119, 2010.
- [27] Jia-Jung Wang, Wei-Chih Hu, Tsiair Kao, Chun-Peng Liu, Shih-Kai Lin, "Development of forearm impedance plethysmography for the minimally invasive monitoring of cardiac pumping function", *J. Biomedical Science and Engineering*, 2011, 4, 122-129.
- [28] Sharma, Ajmer Singh, Bhuvanesh K, Anil K. , " comparison of transthoracic electrical Bioimpedance cardiac output measurement with thermodilution method in post coronary artery bypass graft patients, *Annals of cardiac anaesthesia*, Vol 14-2, 2011.
- [29] Peacock WF, Summers RL, Vogel J, Emerman CE. Impact of impedance cardiography on diagnosis and therapy of emergent dyspnea: the ED-IMPACT trial. *AcadEmerg Med*. 2006 Apr;13(4):365-71.
- [30] PradipBarde, Ajay Bhatnagar, Rajiv Narang, KK Deepak, "Comparison of non-invasive cardiac output measurement using Indigenous impedance cardiography with invasive fick method", *International Journal of Biomedical Research*, 3, 11, 2012.
- [31] A. R. Gujjar, K. Muralidhar, S. Banakal, R. Gupta, T. N. Sathyaprabha, and P. S. Jairaj, "Non-invasive cardiac output by transthoracic electrical bioimpedance in post-cardiac surgery patients: comparison with thermodilution method," *Journal of Clinical Monitoring and Computing*, vol. 22, no. 3, pp. 175–180, 2008.
- [32] J. M. Van De Water, T. W. Miller, R. L. Vogel, B. E. Mount, and M. L. Dalton, "Impedance cardiography the next vital sign technology?" *Chest*, vol. 123, no. 6, pp. 2028–2033, 2003.
- [33] T. Koobi, M. Kahonen, M. Koskinen, S. Kaukinen, and V. M. H. Turjanmaa, "Comparison of bioimpedance and radioisotopemethods in the estimation of extracellular water volume before and after coronary artery bypass grafting operation," *Clinical Physiology*, vol. 20, no. 4, pp. 283–291, 2000.
- [34] Cotter G, Moshkovitz Y, Kaluski E, et al. Accurate, noninvasive continuous monitoring of cardiac output by whole-body electrical bioimpedance. *Chest* 2004;125:1431-40.
- [35] HK Jorgensen, J Bisgaard and T Gilsaa, "Comparison of bioimpedance and oesophageal Doppler cardiac output monitoring during abdominal aortic surgery", *Critical Care* 2012, 16(Suppl 1):P218.
- [36] Belardinelli R, Ciampini N, Costantini C, et al. Comparison of impedance cardiography with thermodilution and direct Fick methods for noninvasive measurement of stroke volume and cardiac output during incremental exercise in patients with ischemic cardiomyopathy. *Am J Cardiol* 1996;77:1293-301.
- [37] Yung GL, Fedullo PF, Kinninger K, et al. Comparison of impedance cardiography to direct Fick and thermodilution cardiac output determination in pulmonary arterial hypertension. *Congest Heart Fail* 2004;10(2 Suppl 2):7-10.
- [38] B. D. Spiess, M. A. Patel, L. O. Soltow, and I. H. Wright, "Comparison of bioimpedance versus thermodilution cardiac output during cardiac surgery: evaluation of a second generation bioimpedance device," *Journal of Cardiothoracic and Vascular Anesthesia*, vol. 15, no. 5, pp. 567–573, 2001.

