Cover image: Heartbeat waveforms
Dear colleagues,

Welcome to the *Physiological Measurement* Highlights of 2010, an exclusive collection showcasing some of the best work published in the journal in the past year. On behalf of the Editorial Board and publishing team, I would like to express our delight in presenting this high-quality compilation to you, and to thank everyone who has been involved and contributed to the journal’s achievements during this time.

In 2011, the journal entered its 32nd year of publication. Back in 1980, it started out as *Clinical Physics and Physiological Measurement*, changing its name in 1993 to the current title. Despite this name change, the clinical aspect of the journal remains as important as ever. *Physiological Measurement* occupies a niche that allows it to bridge the gap between the laboratory and the clinic. *Physiological Measurement* authors and readers are based not only in universities, but also in hospitals and clinics across the world, allowing the journal to facilitate the flow of ideas and understanding between organizations with rather different objectives.

The journal continues to publish papers on a very wide range of subjects, with the 2010 Highlights including papers on the measurement of blood pressure, the control of obesity, the automatic screening of sleep apnea and the delivery of neuroprotective agents to the brain following ischemic stroke.

In 2011 and beyond, the journal will continue to act as a forum for the rapid communication of the latest advances and ideas. We welcome all communities of biomedical engineers, clinical scientists and all others working in physiological measurement science, and invite you to make the journal the home for your future work.

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**Best paper prizewinners (Martin Black award)**

2009
GREIT: a unified approach to 2D linear EIT reconstruction of lung images

2008
Robust heart rate estimation from multiple asynchronous noisy sources using signal quality indices and a Kalman filter
Q Li, R G Mark and G D Clifford

**Most cited papers**

2010
The altered complexity of cardiovascular regulation in depressed patients
Steffen Schulz, Mandy Koschke, Karl-Jürgen Bär and Andreas Voss

Comparative reproducibility of dermal microvascular blood flow changes in response to acetylcholine iontophoresis, hyperthermia and reactive hyperaemia
Sharad C Agarwal, John Allen, Alan Murray and Ian F Purcell

Characterization of textile electrodes and conductors using standardized measurement setups
L Beckmann, C Neuhaus, G Medrano, N Jungbecker, M Walter, T Gries and S Leonhardt

2009
Robust ballistocardiogram acquisition for home monitoring
O T Inan, M Etemadi, R M Ward, L Giovangrandi and G T A Kovacs

Activity identification using body-mounted sensors—a review of classification techniques
Stephen J Preece, John Y Goulermas, Laurence P J Kenney, Dave Howard, Kenneth Meijer and Robin Crompton

Complexity analysis of EEG in patients with schizophrenia using fractal dimension
B S Raghavendra, D Narayana Dutt, Harsha N Halahalli and John P John
Arterial blood pressure measurement and pulse wave analysis—their role in enhancing cardiovascular assessment

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2 UniMQ, Macquarie University, Sydney, Australia

2010 Physiol. Meas. 31 R1

Abstract
The most common method of clinical measurement of arterial blood pressure is by means of the cuff sphygmomanometer. This instrument has provided fundamental quantitative information on arterial pressure in individual subjects and in populations and facilitated estimation of cardiovascular risk related to levels of blood pressure obtained from the brachial cuff. Although the measurement is taken in a peripheral limb, the values are generally assumed to reflect the pressure throughout the arterial tree in large conduit arteries. Since the arterial pressure pulse becomes modified as it travels away from the heart towards the periphery, this is generally true for mean and diastolic pressure, but not for systolic pressure, and so pulse pressure. The relationship between central and peripheral pulse pressure depends on propagation characteristics of arteries. Hence, while the sphygmomanometer gives values of two single points on the pressure wave (systolic and diastolic pressure), there is additional information that can be obtained from the time-varying pulse waveform that enabling an improved quantification of the systolic load on the heart and other central organs. This topical review will assess techniques of pressure measurement that relate to the use of the cuff sphygmomanometer and to the non-invasive registration and analysis of the peripheral and central arterial pressure waveform. Improved assessment of cardiovascular function in relation to treatment and management of high blood pressure will result from future developments in the indirect measurement of arterial blood pressure that involve the conventional cuff sphygmomanometer with the addition of information derived from the peripheral arterial pulse.

Pilot study of temporary controllable gastric pseudobezoars for dynamic non-invasive gastric volume reduction

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2010 Physiol. Meas. 31 131

Abstract
Invasive surgical procedures for gastric volume reduction or bypass have been considered the most effective approach to sustainable long-term weight reduction. However, non-invasive techniques for dynamic volume reduction from inside the stomach are lacking. The aim of this study was to propose temporary, permeable, controllable pseudobezoars for non-invasive, long-term sustainable gastric volume reduction and to test them in pilot human studies. Permeable sac-like carriers made from biocompatible and biodegradable material were filled with expandable superabsorbent fiber and polymer granules. The implements were designed to prevent the expulsion of the pseudobezoars through the pylorus for a controlled time period. The pseudobezoars were administered transorally to two human patients (2M, 78.9 kg/174 cm, girth 88.1 cm, and 89.7 kg/175 cm, girth 95.2 cm). Body weight dynamics, girth, level of satiety, stools, bowel regularity and notable side effects were monitored in three distinct 1 month periods: baseline, therapy and washout. Sonographic verification of the presence of pseudobezoars in the stomachs of both subjects was performed at the end of the therapy month and was repeated at the end of the washout period to examine the clearance of the implements. During the therapy month, both individuals exhibited significant weight and girth reduction (p < 0.05), and substantially increased satiety levels. The patients retained their bowel regularity and did not report any notable side effects. The temporary pseudobezoars were clearly noticeable sonographically in both patients at the end of the therapy month and cleared after its discontinuation. Controllable temporary pseudobezoars were designed and tested in pilot studies.

The 5 x 8 cm carboxy cellulose gauze piece (top, left) was sutured into a pillow-like carrier filled with a proprietary mixture and quantity of fiber and polymer granules and placed into a 000 gelatin capsule (top, right). Immediately after submerging into body temperature HCl solution (pH of 2), the gelatin capsule started disintegrating, and the permeable gauze began moisturizing (bottom, left). After 10–15 min, the pseudobezoar expanded fully to a 12–15 cc implement.
Electrical impedance spectroscopy and diagnosis of tendonitis

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2010 Physiol. Meas. 31 171

Abstract

There have been a number of studies that investigate the usefulness of bioelectric signals in diagnoses and treatment in the medical field. Tendinitis is a musculoskeletal disorder with a very high rate of occurrence. This study attempts to examine whether electrical impedance spectroscopy (EIS) can detect pathological changes in a tendon and find the exact location of the lesion. Experimental tendinitis was induced by injecting collagenase into one side of the patellar tendons in rabbits, while the other side was used as the control. After measuring the impedance in the tendinitis and intact tendon tissue, the dissipation factor was computed. The real component of impedance and the dissipation factor turned out to be lower in tendinitis than in intact tissues. Moreover, the tendinitis dissipation factor spectrum showed a clear difference from that of the intact tendon, indicating its usefulness as a tool for detecting the location of the lesion. Pathologic findings from the tissues that were obtained after measuring the impedance confirmed the presence of characteristics of tendinitis. In conclusion, EIS is a useful method for diagnosing tendinitis and detecting the lesion location in invasive treatment.

Automatic screening of obstructive sleep apnea from the ECG based on empirical mode decomposition and wavelet analysis

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2010 Physiol. Meas. 31 273

Abstract

This study analyses two different methods to detect obstructive sleep apnea (OSA) during sleep time based only on the ECG signal. OSA is a common sleep disorder caused by repetitive occlusions of the upper airways, which produces a characteristic pattern on the ECG. ECG features, such as the heart rate variability (HRV) and the QRS peak area, contain information suitable for making a fast, non-invasive and simple screening of sleep apnea. Fifty recordings freely available on Physionet have been included in this analysis, subdivided in a training and in a testing set. We investigated the possibility of using the recently proposed method of empirical mode decomposition (EMD) for this application, comparing the results with the ones obtained through the well-established wavelet analysis (WA). By these decomposition techniques, several features have been extracted from the ECG signal and complemented with a series of standard HRV time domain measures. The best performing feature subset, selected through a sequential feature selection (SFS) method, was used as the input of linear and quadratic discriminant classifiers. In this way we were able to classify the signals on a minute-by-minute basis as apneic or nonapneic with different best-subset sizes, obtaining an accuracy up to 89% with WA and 85% with EMD. Furthermore, 100% correct discrimination of apneic patients from normal subjects was achieved independently of the feature extractor. Finally, the same procedure was repeated by pooling features from standard HRV time domain, EMD and WA together in order to investigate if the two decomposition techniques could provide complementary features. The obtained accuracy was 89%, similarly to the one achieved using only Wavelet analysis as the feature extractor, however, some complementary features in EMD and WA are evident.

Microscopic findings of the normal patellar tendon and the tendinitis (H–E stain, x400). The tendon injected with collagenase had diffuse, increased cellularity and vascularity, fibrosis around the tendon and myxoid degeneration with disarray of collagen bundles.

DID YOU KNOW?

Physiological Measurement had over 100 000 downloads in 2010
The effects of healthy aging on cerebral hemodynamic responses to posture change

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Abstract
Aging is associated with an increased incidence of orthostatic hypotension, impairment of the baroreceptor reflex and lower baseline cerebral blood flow. The effect of aging on cerebrovascular autoregulation, however, remains to be fully elucidated. We used a novel optical instrument to assess microvascular cerebral hemodynamics in the frontal lobe cortex of 60 healthy subjects ranging from ages 20–78. Diffuse correlation spectroscopy (DCS) and near-infrared spectroscopy (NIRS) were used to measure relative cerebral blood flow (rCBF), total hemoglobin concentration (THC), oxyhemoglobin concentration (HbO2) and deoxyhemoglobin concentration (Hb). Cerebral hemodynamics were monitored for 5 min at each of the following postures: head-of-bed 30°, supine, standing and supine. Supine-to-standing posture change caused significant declines in rCBF, THC and HbO2, and an increase in Hb, across the age continuum (p < 0.01). Healthy aging did not alter postural changes in frontal cortical rCBF (p = 0.23) and was associated with a smaller magnitude of decline in HbO2 (p < 0.05) during supine-to-standing posture change. We conclude that healthy aging does not alter postural changes in frontal cortical perfusion.

An artificial vector model for generating abnormal electrocardiographic rhythms

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Abstract
We present generalizations of our previously published artificial models for generating multi-channel ECG to provide simulations of abnormal cardiac rhythms. Using a three-dimensional vectorcardiogram (VCG) formulation, we generate the normal cardiac dipole for a patient using a sum of Gaussian kernels, fitted to real VCG recordings. Abnormal beats are specified either as perturbations to the normal dipole or as new dipole trajectories. Switching between normal and abnormal beat types is achieved using a first-order Markov chain. Probability transitions can be learned from real data or modeled by coupling to heart rate and sympathovagal balance. Natural morphology changes from beat-to-beat are incorporated by varying the angular frequency of the dipole as a function of the inter-beat (RR) interval. The RR interval time series is generated using our previously described model whereby time- and frequency-domain heart rate (HR) and heart rate variability characteristics can be specified. QT-HR hysteresis is simulated by coupling the Gaussian kernels associated with the T-wave in the model with a nonlinear factor related to the local HR (determined from the last n RR intervals). Morphology changes due to respiration are simulated by introducing a rotation matrix couple to the respiratory frequency. We demonstrate an example of the use of this model by simulating HR-dependent T-wave alternans (TWA) with and without phase-switching due to ectopy. Application of our model also reveals previously unreported effects of common TWA estimation methods.
Characterization and reproducibility of forearm arterial flow during reactive hyperemia

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2010 Physiol. Meas. 31 763

Abstract
Peripheral arterial flow has been assessed for a variety of indications including characterization of endothelial function during reactive hyperemia. However, quantification of this blood flow as a surrogate remains an imperfect reflection of endothelial function. We sought to better characterize hyperemic reaction to (1) elucidate the influence of the endothelial function and (2) assess the reproducibility of our modeling over time. Sixteen normal subjects underwent simultaneous forearm reactive hyperemia testing with a near-infrared system at baseline, baseline +24 h and baseline +27 h. Baseline flow was measured to 3.6 ± 0.2 ml dl−1 min−1, and was highly reproducible 24 and 27 h later. With reactive hyperemia, the blood flow increased to 20.5 ± 4.6 ml dl−1 min−1. Arterial blood flow curves during reactive hyperemia displayed a bimodal pattern, with a peak occurring 59.1 ± 10.6 s after the onset of hyperemia. We believe that this latest peak represents the contribution of endothelial factors to the hyperemic reaction. Modeling of hyperemic curves led to the introduction of a reproducible new parameter (η factor) that reflects the normalized contribution of this second peak. In conclusion, forearm arterial flow during reactive hyperemia revealed a bimodal distribution where functional interpretation allowed distinction of the two components. Basal flow measurements and results of this modeling were reproducible 24 and 27 h later.

Comparability of pulse oximeters used in sleep medicine for the screening of OSA

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2010 Physiol. Meas. 31 875

Abstract
Obstructive sleep apnea syndrome (OSA) is a frequent clinical picture. It is characterized by repetitive respiratory arrest with a consecutive decrease in arterial oxygen saturation (SaO2). In clinical practice, the number of desaturations per hour, oxygen desaturation index (ODI), is used as an important diagnostic criterion. Medical literature, however, mentions different threshold values that are defined as pathological. By means of systematic comparative measurements, the study presented here will examine to what extent the diagnosis and the quantification of OSA severity are affected by the device-specific measurement technique, thus impacting the predictive value of nighttime pulse oximetry in outpatient OSA screening. Different pulse oximeters commonly used in clinical practice were analyzed comparatively regarding technical parameters, temporal dynamics and the reproducibility of measuring results. The measurements were executed simultaneously and time synchronized in a reference group of five test subjects (four males, one female, average age 33.0 ± 9.4 years), in a group of five patients (all males, average age 51.8 ± 18.4 years) and using a simulator (pulse oximeter simulator index 2). All devices underestimate the simulator’s predetermined oxygen desaturation of 10%. The dispersion of values is high. The device-specific characteristics have a significant influence on the collected data. The fundamental weakness of the systems lies in the reproducibility of measuring results (this only seems adequate at a signal resolution in steps of 0.1%) as well as the differing temporal dynamics. In the synchronous use of different systems on patients for the purpose of a direct comparison of devices, the dispersion of values is serious, reaching a fluctuation range of up to factor 1.42. In measuring dynamic events (apneas), different pulse oximeters do not record identical values. This is due to the different internal signal processing of the devices. Without prior knowledge of the pulse oximeter used and the chosen device settings, meaningful interpretation of the measured desaturations is, therefore, ambiguous. Accordingly, different devices require different threshold values in determining the ODI. Standardized technical parameters and the standardization of signal processing are imperative for outpatient screening of sleep-related breathing disorders (SRBD) via pulse oximetry.

Time line illustrating the different stages in the experiment and the flow signal computed from the acquisitions.
Evaluation of an easy, standardized and clinically practical method (SurePrep) for the preparation of electrode–skin contact in neurophysiological recordings

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2010 Physiol. Meas. 31 889

Abstract

The aim of this study was to assess the practicality, reliability and safety of a recently introduced method of skin preparation for EEG recordings. We compared the traditional skin abrasion (SA) method to a method called SurePrep (SP), which creates tiny incisions through the upper epithelial layers. The study comprised three parts. In part 1, forearm recordings (n = 400; ten healthy volunteers) were conducted to examine acute and late (24 h) impedances, skin reactions, as well as the effects on electrode movement artefacts. In part 2, the effect of repeated (up to nine) SP sticks on impedances was examined on the forearm skin in two subjects (n = 99). In part 3, preparation speed and skin impedances were measured from preparation of a standard EEG cap in four subjects (n = 74). Immediately after preparation, skin impedances were a little lower (n.s.) after SA, but the variability in impedances was significantly less after SP (p < 0.01). After one day, there was no mean impedance difference but a greater proportion of SP sites were >10 kΩ. The frequency of immediate skin irritations (93.5%) was much higher after SA compared to 42.5% after SP, but there was no clinically significant difference observed after one day. The SP method exposed interstitial fluid in 5% of cases, while SA caused a wound-like lesion in 4.5% of the sites. No macroscopic blood was observed in any case (n = 400). Three sticks with the SP device produced clinically sufficient (<10 kΩ) impedances in 85% of the cases, and a total of five to six sticks secured a sufficient skin contact in all skin sites examined (n = 99). Preparation of skin contacts in the EEG cap was faster by SP compared to SA in all four study subjects. Our results demonstrate that skin contacts of sufficient quality can be reliably, easily and quickly prepared by the SP method. SP is a useful alternative for EEG recordings in general, although SA may provide the slightly better preserved skin contacts needed for long-term recordings. Notably, SP could facilitate emergency care units, peripheral hospitals and after-hours EEG acquisition by people without special EEG training.

Frequency-difference MIT imaging of cerebral haemorrhage with a hemispherical coil array: numerical modelling

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2010 Physiol. Meas. 31 S111

Abstract

The feasibility of detecting a cerebral haemorrhage with a hemispherical MIT coil array consisting of 56 exciter/sensor coils of 10 mm radius and operating at 1 and 10 MHz was investigated. A finite difference method combined with an anatomically realistic head model comprising 12 tissue types was used to simulate the strokes. Frequency-difference images were reconstructed from the modelled data with different levels of the added phase noise and two types of a priori boundary errors: a displacement of the head and a size scaling error. The results revealed that a noise level of 3 m° (standard deviation) was adequate for obtaining good visualization of a peripheral stroke (volume ≈ 49 ml). The simulations further showed that the displacement error had to be within 3–4 mm and the scaling error within 3–4% so as not to cause unacceptably large artefacts on the images.

The effect of repeated sticks on skin impedances (part 3). Analysis of 99 skin sites showed that skin impedance declines rapidly after the first sticks, and the clinically needed level (<10 kΩ) is reached in 85% of cases after three sticks, and in all cases after six sticks. Lines in graph 5A depict each individual recording. Note that the highest value (65 kΩ) is the limit of scale in our recording device, not the actual skin impedance. The black bar is <5 kΩ, gray 5–10 kΩ.

Images from data simulated for H100 with the small peripheral and small deep strokes and the normal head, without the stroke.

DID YOU KNOW?
The average acceptance to web publication is 28 days
Experimental demonstration of electric field tomography

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2010 Physiol. Meas. 31 S127

Abstract

Electric field tomography (EFT) has recently been introduced in theory. It is a new kind of quasistatic tomography suitable for contactless imaging of biological tissues. Single-channel measurements have already proven the theory. Herein the first multi-channel measuring system for EFT is presented. Experiments on imaging of a test object with different geometries are described. The first EFT images obtained experimentally have been demonstrated and discussed.

Quantification of convection-enhanced delivery to the ischemic brain

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Abstract

Convection-enhanced delivery (CED) could have clinical application in the delivery of neuroprotective agents following ischemic stroke. However, ischemic brain tissue changes such as cytotoxic edema, in which cellular swelling decreases the fractional volume of the extracellular space, would be expected to significantly alter the distribution of neuroprotective agents delivered by CED. We sought to predict and characterize these effects using the magnetic resonance contrast agent gadolinium-diethylenetriamine pentaacetic acid (Gd-DTPA) as a model therapeutic agent. CED was observed using MRI in a normal rat brain and in a middle cerebral artery (MCA) occlusion rat model of brain ischemia. Gd-DTPA was infused to the caudate putamen in the normal rat (n = 6) and MCA occlusion model (n = 6). In each rat, baseline apparent diffusion coefficient images were acquired prior to infusion, and T1 maps were then acquired 13 times throughout the duration of the experiment. These T1 maps were used to compute Gd-DTPA concentrations throughout each brain. In the MCA occlusion group, CED delivered Gd-DTPA to a comparatively larger volume with lower average tissue concentrations. Following the infusion, the total content of Gd-DTPA decreased more slowly in the MCA occlusion group than in the normal group. This quantitative characterization confirms that edematous ischemic tissue changes alter the distribution of agents by CED. These findings may have important implications for CED in the treatment of brain injury, and will assist in future efforts to model the distribution of therapeutic agents.

The removal of EMG in EEG by neural networks

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Abstract

In this paper, it is presented that electromyography (EMG) is a shot noise based on the generation of EMG. A novel filter is proposed by applying a neural network (NN) ensemble where the noisy input signal and the desired one are the same in a learning process. Both incremental and batch mode are applied in the learning process of NNs that is better than generalized NN filters. This NN ensemble filter not only reduces additive and multiplicative white noise inside signals, but also preserves the signals’ characteristics. In clinical EEG and EMG signals processing, the filter is capable of reducing EMG in the clinical EEG, and it is proved that there is randomness in EMG.
2009

GreIT: a unified approach to 2D linear EIT reconstruction of lung images


Consensus on the performance figures of merit for EIT image reconstruction of lung images are important, as (a) uniform amplitude response, (b) small and uniform shape deformation, (c) small ringing artefacts, (d) uniform resolution, (e) limited position error, and (f) high resolution. Such figures of merit must be attained while maintaining small noise amplification and small sensitivity to electrode and boundary movement. This approach represents the consensus of a large and representative group of experts in EIT algorithm design and clinical applications for pulmonary monitoring. All software and data to implement and test the algorithm have been made available under an open source license which allows free research and commercial use.

2008

Robust heart rate estimation from multiple asynchronous noisy sources using signal quality indices and a Kalman filter

Q Li, R G Mark and G D Clifford

Abstract

Physiological signals such as the electrocardiogram (ECG) and arterial blood pressure (ABP) in the intensive care unit (ICU) are often severely corrupted by noise, artifact and missing data, which lead to large errors in the estimation of the heart rate (HR) and ABP. A robust HR estimation method is described that compensates for these problems. The method is based upon the concept of fusing multiple signal quality indices (SQIs) and HR estimates derived from multiple electrocardiogram (ECG) leads and an invasive ABP waveform recorded from ICU patients. Physiological SQIs were obtained by analyzing the statistical characteristics of each waveform and their relationships to each other. HR estimates from the ECG and ABP are obtained by analyzing the statistical characteristics of each waveform and based upon the concept of fusing multiple signal quality indices (SQIs) and a Kalman filter.
The altered complexity of cardiovascular regulation in depressed patients

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Abstract
Major depressive disorders (MDD) are associated with an increased risk for cardiovascular morbidity and mortality. Even if it is known that MDD are accompanied by an autonomic dysbalance with increased sympathetic and/or reduced parasympathetic activity, to date only limited information is available about the degree and complexity of cardiovascular regulation. The aim of this study was to investigate the influence of MDD on the autonomous nervous system and cardiovascular complexity by means of linear and nonlinear indices from heart rate and blood pressure variability (HRV, BPV). From 57 non-medicated patients and 57 matched healthy controls with respect to age and gender HRV and BPV in time and frequency domain, symbolic dynamics, compression entropy, multiscale entropy, detrended fluctuation analysis, Poincaré plot analysis and baroreflex sensitivity were analysed from 30 min short-term recordings. Complexity indices from nonlinear dynamics demonstrated considerable changes in autonomous regulation due to MDD. For the first time we could show that non-medicated depressed patients who were matched with respect to age and gender reveal a significantly changed short-term as well as long-term complexity of cardiovascular regulation. These results suggest substantial changes in autonomic control probably due to a change of interactions between different physiological control loops in MDD.

On the right, examples of tachograms (BBI) and on the left of systograms (systolic blood pressure values over time, SBP) from 30 min recording from a healthy control subject (upper panel) and a non-medicated depressed patient (lower panel). Note the typical lower variability in BBI sequences and the higher SBP values for the depressed patient. Healthy control: meanNN (BBI): 939 ± 84 ms, meanNN (SBP): 116 ± 4 mmHg, depressed patient: meanNN (BBI): 841 ± 31 ms, meanNN (SBP): 132 ± 7 mmHg.

Comparative reproducibility of dermal microvascular blood flow changes in response to acetylcholine iontophoresis, hyperthermia and reactive hyperaemia

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Abstract
Laser Doppler fluxmetry (LDF) can non-invasively measure skin microvascular changes in response to acetylcholine (ACh), local heating of the skin and reactive hyperaemia following arterial occlusion. Various studies have used microvascular changes in response to these stimuli, especially ACh iontophoresis and local heating, as a surrogate marker of endothelial function. There are few data in the literature regarding the comparative reproducibility of microvascular perfusion changes induced by the three stimuli. The aim of this study was to systematically assess and compare the reproducibility of skin microcirculatory function in response to each of these challenges. Ten healthy non-smoking subjects (seven males) median age 36 years (range 23–46), with no history of hypertension, diabetes, coronary artery disease or any connective tissue disorder, were studied. Changes in skin microcirculation in response to ACh iontophoresis, local heating of the skin and post-occlusive reactive hyperaemia, on two separate days (median 31, range 11–42 days), were assessed in all subjects. We measured three parameters: the change in perfusion from baseline perfusion (peak minus baseline perfusion), the relative percentage change in perfusion from baseline (peak − baseline)/baseline × 100 (%) and also the time-to-peak perfusion. The reproducibility of the change in perfusion had coefficients of variation (CV) of 9.3% for local skin heating, 19.4% for reactive hyperaemia and 25.5% for ACh iontophoresis. The relative percentage change in perfusion from baseline was more variable with CVs ranging from 23% to 39%. The coefficient of variation of time-to-peak perfusion was 7.0% for heating, 15.1% for reactive hyperaemia and 10.4% for ACh iontophoresis. We have shown that microcirculatory changes measured by the change in perfusion from baseline and time-to-peak perfusion in response to ACh, post-occlusive reactive hyperaemia and local skin heating had good reproducibility when carried out in a controlled environment with a standardized protocol. Relative change in perfusion had relatively poor reproducibility. The change in perfusion and time-to-peak perfusion for local skin heating were the most reproducible overall.
Characterization of textile electrodes and conductors using standardized measurement setups

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Abstract

Textile electrodes and conductors are being developed and used in different monitoring scenarios, such as ECG or bioimpedance spectroscopy measurements. Compared to standard materials, conductive textile materials offer improved wearing comfort and enable long-term measurements. Unfortunately, the development and investigation of such materials often suffers from the non-reproducibility of the test scenarios. For example, the materials are generally tested on human skin which is difficult since the properties of human skin differ for each person and can change within hours. This study presents two test setups which offer reproducible measurement procedures for the systematic analysis of textile electrodes and conductors. The electrode test setup was designed with a special skin dummy which allows investigation of not only the electrical properties of textile electrodes but also the contact behavior between electrode and skin. Using both test setups, eight textile electrodes and five textile conductors were analyzed and compared.

2009

Robust ballistocardiogram acquisition for home monitoring

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Abstract

The ballistocardiogram (BCG) measures the reaction of the body to cardiac ejection forces, and is an effective, non-invasive means of evaluating cardiovascular function. A simple, robust method is presented for acquiring high-quality, repeatable BCG signals from a modified, commercially available scale. The measured BCG waveforms for all subjects qualitatively matched values in the existing literature and physiologic expectations in terms of timing and IJ amplitude. Additionally, the BCG II amplitude was shown to be correlated with diastolic filling time for a subject with premature atrial contractions, demonstrating the sensitivity of the apparatus to beat-by-beat hemodynamic changes. The signal-to-noise ratio (SNR) of the BCG was estimated using two methods, and the average SNR over all subjects was greater than 12 for both estimates. The BCG measurement was shown to be repeatable over 50 recordings taken from the same subject over a three week period. This approach could allow patients at home to monitor trends in cardiovascular health.

Test setup for the characterization of electrodes.

Ensemble averages for 50 recordings from the same subject taken at random times during the day for a 3 week period. Amplitudes are not normalized, though the signals are aligned in time using the J wave. SNR estimates were 38.5 using the maximum likelihood method and 62.0 using the correlation coefficient method.

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Activity identification using body-mounted sensors—a review of classification techniques

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Abstract
With the advent of miniaturized sensing technology, which can be body-worn, it is now possible to collect and store data on different aspects of human movement under the conditions of free living. This technology has the potential to be used in automated activity profiling systems which produce a continuous record of activity patterns over extended periods of time. Such activity profiling systems are dependent on classification algorithms which can effectively interpret body-worn sensor data and identify different activities. This article reviews the different techniques which have been used to classify normal activities and/or identify falls from body-worn sensor data. The review is structured according to the different analytical techniques and illustrates the variety of approaches which have previously been applied in this field. Although significant progress has been made in this important area, there is still significant scope for further work, particularly in the application of advanced classification techniques to problems involving many different activities.

Complexity analysis of EEG in patients with schizophrenia using fractal dimension

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Abstract
We computed Higuchi's fractal dimension (FD) of resting, eyes closed EEG recorded from 30 scalp locations in 18 male neuroleptic-naïve, recent-onset schizophrenia (NRS) subjects and 15 male healthy control (HC) subjects, who were group-matched for age. Schizophrenia patients showed a diffuse reduction of FD except in the bilateral temporal and occipital regions, with the reduction being most prominent bifrontally. The positive symptom (PS) schizophrenia subjects showed FD values similar to or even higher than HC in the bilateral temporal-occipital regions, along with a co-existent bifrontal FD reduction as noted in the overall sample of NRS. In contrast, this increase in FD values in the bilateral temporo-occipital region was absent in the negative symptom (NS) subgroup. The regional differences in complexity suggested by these findings may reflect the aberrant brain dynamics underlying the pathophysiology of schizophrenia and its symptom dimensions. Higuchi's method of measuring FD directly in the time domain provides an alternative for the more computationally intensive nonlinear methods of estimating EEG complexity.
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Epifluorescence image of HeLa cells incubated at 37 °C for 1 h with 5 μM concentration of functionalized CNTs (f-CNTs).
We would like to thank all of our authors, referees, board members and readers across the world for their vital contributions to the work and progress of *Physiological Measurement*. 