Comparison of the MindG wristband with the established MotionWatch device for monitoring of physical activity and sleep

BACKGROUND

This document provides comparison of our physical activity monitoring device – the MindG wristband – with the MotionWatch and corresponding analytical software: MindPax cloud and MotionWare. MotionWatch is a monitoring device that has become a standard device for monitoring of physical activity and sleep.

In our comparison, we focused on three main topics: (i) we compared the amplitude of the signals measured by both devices, (ii) we evaluated the capabilities of the system in sleep detection, (iii) we used the signals from both of the devices to assess the circadian parameters of the participants’ sleep. In order to perform the comparison, we organized a simultaneous measurement of 20 persons’ everyday activity with both devices for a period of two months.

METHODS

Amplitude comparison

The different approaches to raw accelerometric data aggregation caused discrepancies in the signals. Therefore, the data were filtered by moving average filter of length equivalent to one hour period to eliminate the effects of aggregation. The signals from MindG and MotionWatch were compared by the Spearman’s correlation coefficient complemented by 95% confidence interval estimated by bootstrap.

Sleep detection

The detection consists of two main parts: (1) sample-based classification of the actigrams into sleep and non-sleep and (2) detection and grouping of the sleep intervals (non-interrupted sleep) with subsequent estimation of the fall-asleep and wake-up times. The first part is done using a linear model estimated using logistic regression; the model is then used to obtain “sleepiness” measure of each actigram sample. In the second part, the sleepiness is thresholded to obtain the sleep intervals that are then post-processed using rule based algorithm to obtain the fall-asleep and wake up times.
Circadian rhythmicity analysis

The nonparametric analysis of the circadian rhythmicity was performed by computation of the interdaily stability (IS), the interdaily variability (IV), the relative amplitude (RA), L5, L5 start time, M10 and M10 start time parameters [1]. The computed values were summarised and compared to a reference implementation [2] by MotionWare software applying a resistant regression analysis.

RESULTS

Amplitude comparison

The correlation analysis of the signals yielded average correlation between the signals 0.738 (median 0.830), which indicates strong relationship between the signals. Comparison of amplitudes of both signals is depicted in Figure 1.

Sleep detection

Three-fold cross-validation was used to assess the performance of the algorithm. The performance of the sleep model was measured by accuracy, the Dice coefficient and the ROC curve resulting in the accuracy 0.941, the Dice index 0.911 and the area under ROC 0.969. The second part of the detection - fall asleep and wake up times - was assessed by the absolute deviance of the fall asleep and wake up times from the ground truth (sleep questionnaires) in minutes and resulted in the mean error of 27 minutes for the fall asleep time, 22 minutes for the wake up time. The results are shown in Figure 2.
Circadian rhythmicity analysis

The nonparametric characteristics were computed in 7 days long sliding window. We compared the values from MindG system to those computed on MotionWatch by linear regression estimated by robust methodology. Firstly, we estimated which data points are outliers by robust least quantile regression (LQS) [3]. The data point whose residuals were higher than 2.57 (0.005 quantile of standard normal distribution) times residual variance estimate from LQS model, were denoted as outliers and excluded from further analysis. Secondly, the resistant least trimmed squares regression (LTS) was utilized to conclude the comparison [3].

The estimated robust model coefficients show that the values of interdaily stability and variability correlate satisfactorily between the two systems - see Figure 3 - as indicated by regression coefficients close to 1 (0.96 for IS, 1.13 for IV), with systematics average differences (-0.09 for IS, 0.16 for IV). On the other hand, the values are on average 0.11 lower in case of interdaily stability and 0.16 higher in case of interdaily variability. The remaining parameters (RA, L5 and M10) show greater variability in the relationship. The difference originates in the different aggregation method as those values are based on sum of the signal elements (the L5 and M10 directly, the relative amplitude as a function of L5 and M10). These values are significantly lower in the MindPax cloud.

The L5 start time value coincides among the systems in 80.8% repeat of cases and the times differing up to 2 hours constitute 89.1% of the cases. The average difference in the L5 start times between the MotionWatch and MindG is 7.64 mins. The M10 start time value coincides in 48.3% and 80.1% of the cases with the average difference of 21.1 minutes.

Figure 3. Example of non-parametric parameters comparison

“ We are helping people who suffer from bipolar affective disorder. ”
CONCLUSION

The comparison showed the amplitude of signals is highly correlated, even though the method of raw accelerometric data aggregation differs. The difference in sleep detection is sufficiently accurate for use in scientific studies as well as for healthcare application. The comparison of circadian parameters showed several systematic differences nevertheless for analysis of relative changes in time or among groups the differences are negligible. Furthermore, in literature are available different implementations of circadian parameters [5]. While MotionWare implementation origins from classical paper of [1], the MindPax cloud implementation is based on newer contributions [4] which is more suitable for clinical practice. More detailed information could be found in the Appendix which accompanies this White paper.

REFERENCES