at an early stage and in absence of a clinician. The predicted physiological parameters such as forced expiratory volume in the first second expressed as percentage of a maximum value (FEV_1%), six-minute walking test, Modified Medical Research Council (MMRC) dyspnoea scale, and body mass index (BMI) are weighed using particle swarm optimization and the state of the patient is fuzzified in accordance to the GOLD criteria. Although useful, all these methods require signals which are only available in hospitals or laboratories and can currently not be provided by automated wireless remote detection.

Newandee et al. [152] have studied COPD severity classification using principal component and cluster analysis on heart rate variability (HRV) parameters using heart rate, blood pressure, and respiration signals. Results demonstrated that these two groups could be differentiated with greater than 99.0% accuracy. Furthermore, differences on the same HRV parameters between all four severity levels of COPD subjects were also investigated. These groups were differentiated with over 88.0% accuracy. However, data were acquired under controlled laboratory conditions.

The CHRONIOUS system [153] offers an intelligent system for the analysis and the real-time evaluation of patient’s condition. A hybrid classifier has been implemented on a personal digital assistant, combining a support vector machine, a random forest, and a rule-based system to provide a categorization scheme for the early and in real-time characterization of a COPD episode. This is followed by a severity estimation algorithm which classifies the identified pathological situation in different levels. The achieved characterization accuracy has been found 94%. Sensor data were acquired by external sensors and several devices attached to a wearable jacket during daytime making the system rather cumbersome and difficult to be used in clinical practice.

In our previous work [154] it has been shown that probabilistic daytime activity biomarkers derived from an unobtrusive activity monitor data by using topic modelling techniques are able to cluster subjects with and without COPD with 86% of accuracy. Patients’ monitoring and classification using night-time data may offer several advantages since, spending one third of their life with sleeping, it belongs to one of the prime activities humans pursue in which disease trends can be better observed. Moreover, compared to daytime hours, sleeping hours may offer a better trade-off between patients' comfort, sensor unobtrusiveness and signal quality [148].

7.2.2 Sleep in patients with COPD

Sleep disturbance, such as sleep fragmentation during the night, is common in patients with COPD [96], and is a major complaint after dyspnoea and fatigue [97]. Despite the high prevalence of disturbed sleep in COPD, night-time symptoms are often underestimated and are not a focus of current disease management [96].

Sleep in patients with COPD is usually assessed using a patient-completed diary that consists of asking patients to record their sleep duration, recalled sleep disruptions, and a sleep score that reflects the degree of perceived sleep disruption [155]. Self-reported measures of sleep duration and quality provide a useful insight into the patient’s perception of the nocturnal burden of their disease, but their precision and reliability are poor compared to objective measures of sleep [96].

Sleep laboratory measurement tests, such as polysomnography (PSG), offer a well-validated, reliable and reproducible method of collecting sleep data, but they are expensive, intrusive and require patients to attend a clinic for overnight recording.