

3.5.3 Validation with healthy participants

In this validation, we quantified the accuracy of the system in detecting the nine performance classes listed in Table III. Four healthy participants (all male, 26 ± 2.5 years old) were individually asked to perform nine exercise sessions of at least ten repetitions in the university sport centre. An expert personal trainer instructed the participants to perform the exercises as required according to the protocol and supervised the whole data collection. After a first set of repetitions to familiarize with the exercise, ten continuous repetitions were recorded for the evaluation. The data gathering started with the acquisition of one correct session of ten repetitions during the Teach-mode. Afterwards participants were asked to perform the repetitions using the Train-mode.

3.5.4 Evaluation with COPD patients

Subsequently to the validation, we tested the training system in a pilot intervention study with COPD patients. For this evaluation, seven COPD patients (age 60 ± 10 years) were recruited while they were following a rehabilitation program in a specialized centre for pulmonary diseases. The patients ranked a COPD GOLD score between II and III, FEV₁ was between 37% and 69% and FEV₁/FVC was between 27% and 69%. After being instructed on the exercise execution, one Teach-mode session for each exercise was performed with one therapist guiding the patient in order to perform correct movements and rejecting sessions that were not performed correctly. After completing the Teach-mode for all the exercises the therapist did not interact anymore with the patients to simulate individual training exercise executions. The patients started the Train-mode session by touching the start button on the smartphone's screen and then began with the training. During the exercise execution, the application gave audio feedback if an erroneous repetition was detected and asked the patients to terminate the session when ten repetitions were counted. While the patients were performing the exercises, one therapist judged each repetition, according to the movement errors defined before and annotated the performance for each repetition in a table. After the recordings, the annotations were digitized. Furthermore, a ground truth was derived after the recordings by reviewing the raw sensor data time series and labelling error classes for each exercise repetition based on the data. The ground truth labels were aligned according to the peaks and valleys in the sinusoidal exercise pattern. Speed and range of motion of each repetition were then calculated according to Table III. In total each patient was asked to perform three sessions of ten repetitions per each of the six exercises. Patients could take a break in between if they wished to do so. Data was acquired in two sessions at separate days. During the first session four patients (P1, P2, P3, P4, 1 male and 3 female) were examined and during the second session the remaining 3 patients (P5, P6, P7, 2 male and 1 female). In the first session, patients (P1-P4) were specifically asked to alternate their training such that at least one other exercise was done in between Teach-mode and Train-mode performance of an exercise. With this protocol, we intended to avoid excessive effects of exercise memorisation. In the second session, patients (P5-P7) were not asked for alternating exercises. In our subsequent analysis we did not observe performance differences between the two sessions.