Streszczenie rozprawy doktorskiej lek. Piotra Jankowskiego p.t. „Zastosowanie przenośnych spirometrów w diagnostyce obturacyjnych chorób płuc" w języku angielskim

The use of portable spirometers in the diagnosis of obstructive lung diseases

Spirometry plays a crucial and well-documented role in the diagnosis and monitoring of obstructive lung diseases, including Chronic Obstructive Pulmonary Disease (COPD) and asthma. Despite this, the full potential of spirometry as a diagnostic and monitoring tool for individuals with these conditions is not yet fully utilized. This is due to the still limited availability of spirometers, especially in healthcare facilities in rural areas, time pressure on doctors, lack of regular staff training, technical issues (e.g., irregular servicing and calibration of devices), the use of outdated reference values, and concerns about meeting the standards of tests according to current guidelines.

In the 21st century, the development of technology has made it possible to create portable spirometers (PS), which are characterized by their lightness, ease of use, and relatively low cost. Thanks to Bluetooth technology (short-range wireless technology), measuring devices can connect to mobile phones, making them usable almost anywhere – in small primary healthcare facilities or even in patients' homes. Some models of PS offer automatic analysis of test accuracy according to the American Thoracic Society/European Respiratory Society (ATS/ERS) guidelines, indicating errors that affect the final result and its interpretation. Moreover, most PS devices use the latest Global Lung Initiative (GLI) 2012 reference values, and some models do not require regular servicing or calibration. It is also important to note that the accuracy of PS is comparable to the results obtained using stationary spirometers found in spirometry laboratories.

Wider access to PS could significantly contribute to earlier diagnosis of obstructive diseases in primary healthcare settings, enabling the implementation of early therapeutic interventions. Portable spirometers are also used for monitoring other lung diseases beyond obstructive ones. By allowing measurements in the patient's home, PS devices enable the monitoring of cystic fibrosis, the assessment of the effectiveness of antifibrotic treatment in patients with interstitial lung diseases, early detection of pulmonary complications in recipients of allogeneic hematopoietic stem cell transplants, and lung function monitoring in patients who have undergone lung transplants.

Beyond stationary spirometry labs, PS can support the development of proactive strategies for the early detection of COPD. Due to the mobility of these devices, spirometry screening tests can be conducted in public places such as airports, train stations, or shopping malls. The issues related to the use of portable spirometers in the diagnosis of COPD were the central theme of all four publications that make up this doctoral dissertation.

The specific objectives of the publications included:

1) evaluating the effectiveness of proactive strategies using portable spirometers for diagnosing COPD in high-risk individuals,

2) assessing the feasibility of using portable spirometers in different settings:

a) in primary healthcare on a nationwide scale,

b) in hospitalized patients in pulmonology and cardiology departments,

c) during spirometry screening campaigns conducted outside healthcare facilities.

3) estimating the prevalence of COPD diagnosed using portable spirometers among patients with risk factors and comparing these results with the prevalence observed in studies using conventional stationary spirometers,

4) analyzing the accuracy of tests conducted using portable spirometers and identifying the most common errors.

The first three publications present original research results, while the fourth publication is a systematic review.

The first study, *Public spirometry campaign in chronic obstructive pulmonary disease screening - hope or hype?* (doi:10.5603/ARM.2017.0024), aimed to evaluate the effectiveness of a public spirometry screening campaign in identifying individuals with airway obstruction suggesting COPD. The spirometry campaign was conducted among passers-by at a major city railway station. The study included individuals over 40 years of age with a smoking history exceeding 10 pack-years, who were invited to complete a questionnaire and perform spirometry. Of the 905 invited individuals, only 178 (19.6%) agreed to participate. Airway obstruction was detected in 22 (12.3%) participants, and 37 (20.7%) had results close to the lower limit of normal. Only 15 (25.4%) patients attended a follow-up visit at a stationary spirometry laboratory to confirm the result. Data extrapolation suggested that airway obstruction was detectable in 10.7% of participants. The study results indicate that public spirometry campaigns are ineffective in detecting COPD, and smokers, even with clear respiratory symptoms, are reluctant to undergo spirometry.

The second study, *Active screening for COPD among hospitalized smokers - a feasibility study* (doi:10.1177/2040622320971111), aimed to evaluate the effectiveness of using portable spirometers to diagnose COPD in high-risk patients hospitalized in pulmonology and cardiology departments. The study included 188 patients aged ≥40 years with a smoking history (≥10 pack-years); 116 individuals (62%) agreed to participate. Spirometry was conducted at the patient's bedside. Spirometry using portable spirometers was performed correctly in 94 individuals (81%). COPD was diagnosed in 32 (34%) of them, including 9 for the first time. Newly diagnosed patients were younger, had a longer period of smoking cessation, and had milder symptoms compared to those with a prior diagnosis. Most new cases showed mild to moderate airflow limitation. In conclusion, the study suggested that this spirometry screening strategy could effectively increase COPD detection in hospitals, especially among former smokers with mild symptoms.

The third study, *The use of mobile spirometry with feedback quality assessment in primary care setting - A nationwide cross-sectional feasibility study* (doi:10.1016/j.rmed.2021.106472), aimed to assess the feasibility of portable spirometers in primary healthcare in Poland. Between September 2018 and September 2019, 10,936 spirometries were performed on 9,855 patients. All medical personnel performing the tests underwent a brief, two-hour training session. Spirometry was performed on patients presenting respiratory symptoms or belonging to a high-risk group for obstructive diseases. The study analyzed the most common errors made during spirometry. Among all tests, 49% met the technical accuracy criteria, with the most frequent error being the failure to achieve a plateau in the final phase of exhalation (17.7%). A higher percentage of accurate tests was noted when performed by medical personnel over 40 years old and when the test was repeated during the same visit. Airway obstruction was found in 17% of technically accurate tests. The study's results suggest that portable spirometers can be effectively used in primary healthcare. To improve test quality, more intensive and regular staff training is necessary.

The final, fourth publication in this dissertation is a systematic review: *How to enhance the diagnosis of early stages of chronic obstructive pulmonary disease (COPD)? The role of mobile spirometry in COPD screening and diagnosis - a systematic review* (doi:10.3390/arm92020018). It aimed to evaluate the prevalence of COPD diagnosed with portable spirometers among high-risk patients and compare these results with data obtained from traditional stationary spirometers. A systematic review of the literature was conducted to identify relevant studies published in English from 1958 to December 7, 2021. Data sources

included PubMed, the Cochrane Central Register of Controlled Trials, and Embase. Keywords related to COPD, spirometry, and screening were used in the search.

The review included studies meeting the following criteria:

a. spirometry was performed on individuals aged >35 years with a smoking history (≥10 pack-years),

b. the study included a bronchodilator test using either a portable or traditional spirometer,

c. the aim was to assess the prevalence of persistent airway obstruction.

A total of 28 studies published between 2007 and 2021 were included in the analysis. The average COPD diagnosis rate using portable spirometers was 20.27%, slightly lower than the 24.67% obtained using traditional spirometers. In 11 of the analyzed publications, the bronchodilator test was conducted with a portable spirometer.

The results of the systematic review indicate that portable spirometers have only a slightly lower effectiveness in screening for COPD compared to traditional spirometers. These devices can be a reliable diagnostic tool, enabling the bronchodilator test and confirming irreversible airflow limitation, which, in smokers, is the basis for diagnosing COPD.

In conclusion, the results of the conducted studies and the systematic literature analysis indicate that portable spirometers can be successfully used for detecting COPD in various clinical and population settings.

The conducted research allowed for the formulation of the following conclusions corresponding to the research objectives:

1. portable spirometers can be effectively used in proactive diagnostic strategies aimed at detecting COPD in high-risk individuals.
2. portable spirometers can be successfully applied in COPD diagnostics across various clinical settings, including primary healthcare, hospitalized patients, and screening programs conducted outside medical facilities.
3. the prevalence of COPD, diagnosed using a portable spirometer in patients with risk factors, is approximately 20% and is only slightly lower than the detection rate obtained with conventional spirometers.
4. an analysis of the most common errors in spirometric examinations has shown that proper technical preparation and the experience of medical personnel are crucial for result quality. To improve measurement accuracy, regular training and control procedures should be implemented.