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REVIEW

Respiratory sounds in healthy people: A systematic review

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Computerised respiratory sound analysis;
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Healthy population

Summary
Background: There is a lack of systematised information on respiratory sounds of healthy people. This impairs health professionals from differentiating respiratory sounds of healthy people from people with respiratory diseases, which may affect patients' diagnosis and treatment. Therefore, this systematic review aimed to characterise respiratory sounds of healthy people.
Methods: The Web of knowledge, MEDLINE, EMBASE and SCOPUS databases were searched and studies using computerised analyses to detect/characterise respiratory sounds in healthy people were included. Data were extracted using a structured table-format.
Results: Sixteen cross-sectional studies assessing respiratory sounds in 964 subjects (aged 1day-70yrs) were included: 13 investigated normal respiratory sounds (frequency, intensity and amplitude) and 3 adventitious respiratory sounds (crackles and wheezes). The highest sound frequencies were observed at the trachea (inspiration: 447–1323 Hz; expiration: 206–540 Hz). Women (444–999 Hz) and infants (250–400 Hz) presented the highest frequencies at maximum power. Inspiratory sounds were more intense at the left posterior lower lobe (5.7–76.6 dB) and expiratory sounds at the trachea (45.4–85.1 dB). Nevertheless, studies establishing direct comparisons between inspiratory and expiratory sounds showed that inspiratory sounds presented the highest intensities ($p < 0.001$). Amplitude was higher at the left upper anterior chest (1.7 ± 0.8 V) and lower at the right posterior lower lobe (1.2 ± 0.7 V). Crackles were the adventitious respiratory sound most frequently reported.
Conclusions: Respiratory sounds show different acoustic properties depending on subjects' characteristics, subjects' position, respiratory flow and place of recording. Further research with robust study designs, different populations and following the guidelines for computerised respiratory sound analysis are urgently needed to build evidence-base.

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Contents

Introduction

Respiratory auscultation performed with a conventional stethoscope is an assessment method used by many health professionals to evaluate and monitor patients with respiratory diseases [1,2]. In clinical practice, respiratory diseases may be diagnosed when normal respiratory sounds (NRS) are perceived as having frequencies and intensities that differ from normal [3] or when adventitious respiratory sounds (ARS) are present, namely crackles and wheezes [4,5]. Current research have been reporting on the potential of ARS to provide useful clinical information, as they are directly related to movement of air, changes within lung tissue and morphology and presence of secretions [6]. It is also known that different sections of the airways produce ARS with different characteristics (i.e., their duration and frequency varies; more proximal airways produce coarser crackles and higher frequency wheezes [4,7—9]), which can aid to localise the respiratory problem within the tracheobronchial tree. However, as the detection of ARS is usually performed with conventional stethoscopes, the correct interpretation of these sounds is critically dependent on the experience and hearing ability of the users [10], their knowledge about the range of frequencies and intensities that can be found in NRS and ARS [3] and their capacity to use the same nomenclature and memorise different sound patterns [11]. Furthermore, it can also be influenced by the stethoscope properties [12].

To overcome these limitations, research efforts are being conducted to automatically detect, quantify and characterise respiratory sounds, namely through computerised respiratory sound analysis [13]. Computerised respiratory sound analysis consists on recording subjects' respiratory sounds with an electronic device and then analysing and classifying the acoustic signal based on specific characteristics [14]. This innovative approach is being continuously updated with the use of electronic methods of signal transduction, conditioning, amplification and algorithms for a precise and automatic detection/classification of NRS and ARS [15—17]. However, reports on the classification of computerised respiratory sounds in healthy subjects are dispersed in the literature, unclear and mixed with findings from non-computerised respiratory sound analyses [18,19]. The lack of systematised information impairs health professionals from using this objective technology in their clinical practice and its use could potentially enhance patients' diagnosis treatment and monitoring.

Thus, the purpose of the present systematic review was to characterise respiratory sounds of healthy people through the use of computerised respiratory sound analysis.

Methods

Information sources and search strategy

A systematic electronic literature search was conducted from February to April 2013 on the following electronic databases: Pubmed (1950—2013), Science Direct (1823—2012), Web of Knowledge (1970—2012) and Scopus (1960—2013). A previous search was conducted in the Cochrane database to exclude the existence of reviews with the same purpose as the present one. Search terms were based on a combination of the following keywords: ("healthy people" OR "healthy population" OR "normal people" OR "normal population" OR healthy OR child*) AND ("computerised analyses" OR "digital auscultation" OR "electronic auscultation" OR "automatic auscultation") AND ("breath sounds" OR "lung sounds" OR "respiratory