Marcus Fernando da Silva Praxedes
(Organizador)

HEALTH PROMOTION AND QUALITY OF LIFE

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Apresentamos o terceiro volume do livro "Health promotion and quality of life". O objetivo principal é apresentar de forma categorizada e clara estudos desenvolvidos em diversas instituições de ensino e pesquisa nacionais e internacionais. Estão reunidos aqui trabalhos referentes à diversas temáticas que envolvem e servem de base para ações voltadas à promoção de saúde e qualidade de vida.

São apresentados os seguintes capítulos: Utilização de oxigenoterapia hiperbárica e seus benefícios no tratamento de feridas; Aplicação da argiloterapia no clareamento de manchas de pele e tratamento de pacientes com cicatrizes por acne; Relato de caso em fisioterapia neurofuncional: paralisia facial periférica; Amiloidose cardíaca: relato de caso em hospital de Aracaju; Impacto da pandemia Covid-19 no desenvolvimento infantil: uma revisão de literatura; Higienização das mãos no controle de infecção relacionada à assistência à saúde em unidades de terapia intensiva neonatal; Métodos hormonais e não hormonais disponíveis para contracepção masculina; O exercício da sexualidade em mulheres de meia-idade; O uso do CPAP pré-treino aumenta a VO2 máx de atletas de jiu jitsu; Use of ultrasound imaging in the assessment of diaphragmatic dysfunction in patients whit COPD: An evidence-based review e Anticoagulação em pacientes com coagulopatia nas manifestações graves de Covid-19: protocolo de revisão de literatura.

Os trabalhos científicos apresentados nesse livro poderão servir de base para uma melhor prática de assistência em saúde. Nesse sentido, a Atena Editora se destaca por possuir a estrutura capaz de oferecer uma plataforma consolidada e confiável para estes pesquisadores exporem e divulguem seus resultados.

Marcus Fernando da Silva Praxedes

SUMÁRIO

USE OF ULTRASOUND IMAGING IN THE ASSESSMENT OF DIAPHRAGMATIC DYSFUNCTION IN PATIENTS WHIT COPD: AN EVIDENCE-BASED REVIEW

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ABSTRACT: **Aims:** We reviewed the current literature about the role of ultrasound imaging in assessing diaphragmatic mobility and dysfunction in patients with chronic obstructive pulmonary disease (COPD). **Methods:** We performed a literature search in the PubMed, LILACS, and Google Scholar databases. We included original studies (observational or experimental) investigating mobility and/or diaphragmatic dysfunction using ultrasound in adults with COPD. Review articles, editorials, case reports, letters to the editor, animal studies, other outcomes, and studies in children were excluded. **Results:** Diaphragmatic ultrasound appears to be a useful prognostic marker of outcomes in pulmonary rehabilitation and the analysis of stretching and releasing techniques. In patients requiring invasive or non-invasive mechanical ventilation, ultrasound seems to aid the weaning process and its success and correlate with mortality and length of hospital stay. In the analysis of patients at rest, diaphragmatic mobility is lower when compared to healthy individuals, whereas thickness did not show any significant differences. Mobility appears to correlate positively with disease severity and clinical factors such as PaCO2, dyspnea, and pulmonary hyperinflation. **Conclusions:** Diaphragmatic ultrasound is a helpful tool for analyzing diaphragmatic dysfunction in COPD patients. It appears to be a good prognostic predictor and a tool for analyzing patients' respiratory muscle condition.

KEYWORDS: Diaphragmatic, chronic obstructive pulmonary disease, ultrasound.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a disease characterized by a chronic airflow obstruction associated with an inflammatory response of the lungs with systemic repercussions, mainly caused by smoking habits, generally progressive, disabling, and not fully reversible. Its main symptoms are dyspnea, cough, and/or expectoration, though some patients, especially in the early stage of the disease, can be asymptomatic[1].

We can observe respiratory muscle dysfunction in COPD, especially the diaphragm, which often presents muscle shortening and reduction of the zone of apposition, mainly due to hyperinflation caused by the disease, which reduces its contraction strength and effectiveness of the inspiratory action [2]. Diaphragmatic dysfunction in patients with COPD is disabling and is associated with mortality among these patients. The analysis of such dysfunction has been widely used in COPD patients. The diaphragm is not amenable to direct assessment due to its location and complex structure. The tools available for diaphragmatic dysfunction assessment are limited. Traditionally, radiographic assessment measures, such as fluoroscopy, are the main methods used for diaphragmatic mobility assessment [3].

A method currently being used is the diaphragmatic ultrasound, with which it is possible to analyze diaphragmatic mobility, thickness, and excursion velocity. Both factors seem to correlate with lung volume and the severity and progression of the disease [4–6]. Diaphragmatic ultrasound has advantages over other methods of diaphragmatic analysis, such as chest radiographs, fluoroscopy, or tomography. It does not require radiation, is low-cost, non-invasive, and, most importantly, can be performed immediately at the bedside, integrated with the physical examination results and clinical impression, with real-time dynamic muscle analysis [7].

This technique can be used in many different contexts, whether in the ambulatory setting, for laboratory pulmonary function testing, hospital settings, or intensive care, and appears to be helpful in the objective assessment of pulmonary function and neuromuscular disorders [8]. Although the diaphragmatic motion has frequently been studied by ultrasound, reference values for diaphragmatic mobility are not well established yet [9]. Thus, we reviewed the existing literature about the role of ultrasound imaging when assessing diaphragmatic mobility and dysfunction in COPD patients.

METHODS

We conducted a literature review using a systematic approach to search and select primary studies and synthesize data. The literature search was performed in PubMed, LILACS, and Google Scholar databases, without date and language restrictions. The search strategy used was (“Diaphragmatic Mobility” OR “diaphragmatic Dysfunction”) AND (ultrasound OR ultrasonography). The PubMed search was performed in July 2021, and the LILACS and Google Scholar searches were performed in September 2021. We selected original studies (observational or experimental) that investigate diaphragmatic mobility and/or dysfunction using ultrasound in adults with COPD. Review articles, editorials, case reports, letters to the editor, animal studies, other outcomes, and studies in children were excluded. Three investigators performed the study selection and data extraction.

The extracted data included first author's name, year of publication, study location, study design, population size, ultrasound technique used to measure diaphragmatic function (B-mode and/or M-mode, equipment used, probe type, body area assessed, measurements taken), and main results.

The data synthesis was qualitative, with tables and narrative text, since meta-analysis is not applicable due to the high heterogeneity among the selected studies regarding design and outcomes.

RESULTS

Out of the 1,373 articles identified in the databases, we selected 20 studies for this review, including one randomized clinical trial, 12 prospective observational or cross-sectional studies, one prospective cohort study and six case-control studies **(Figure I)**.

Two studies were conducted in patients undergoing a Cardiopulmonary Rehabilitation program [10–13] and one study evaluated diaphragmatic mobility (DM) after diaphragmatic stretching and release techniques [8]myopathy; and 10, neuropathy. Diaphragmatic ultrasound appears to be a helpful prognostic marker of outcomes in both pulmonary rehabilitation and analysis of diaphragmatic stretching and release techniques **(Table I).**

Seven studies have reported the use of diaphragmatic ultrasound, for analysis of diaphragmatic dysfunction, in critically ill COPD patients requiring mechanical ventilation and with disease exacerbation [14–20]. In such cases, they used diaphragmatic ultrasound to predict the success and/or failure of mechanical ventilation or noninvasive ventilation weaning. It was also possible to use it as an index of respiratory effort in mechanically ventilated patients.

Measures of diaphragmatic thickening and mobility were frequently correlated with increased mortality and length of ICU stay in these COPD patients. The summary of the results is described in **Table II**.

Six articles evaluated diaphragmatic mobility at rest; one of them performed the analysis of interobserver (between two observers) measurements [10–13,21,22], diaphragmatic thickness, and or thickening ratio was analyzed by four studies [23–26]. At rest, no difference was observed in interobserver measurements; no difference was observed between sitting or lying positions. The diaphragmatic mobility of COPD patients seems lower when compared to healthy individuals and appears to correlate positively with disease severity and clinical factors such as $PaCO_2$, dyspnea, and lung hyperinflation[10,11,21,27]. In three studies, no difference was observed in diaphragmatic thickness between COPD patients and healthy individuals[23,24,26]. There was also no correlation with disease severity, the number of exacerbations, dyspnea, gender, age, or BMI[11,21,27,28]. One study observed less diaphragmatic thickness in COPD patients when compared to healthy individuals, but there was no correlation between diaphragmatic measurements and

FEV1[25], as shown in **Table III**.

DISCUSSION

Diaphragmatic dysfunction is characterized by partial or total loss of diaphragmatic contractibility; such dysfunction, associated with pulmonary pathological processes, can cause dyspnea, decreased physical and ventilatory capacity in COPD patients, and even evolve, in more severe cases, to respiratory failure in these patients [3,21,29]. Diaphragmatic measurements such as mobility, thickness, thickening ratio, among others, can help identify and analyze this dysfunction.

FEV1, often used as the main parameter to establish the severity and progression of the disease, has been positively correlated with these measurements [11]. Pulmonary hyperinflation, airflow obstruction, and low ventilatory capacity in COPD patients seem to interfere with diaphragm mobility. Thus, the decrease in diaphragmatic mobility, its disfunction, correlates positively with disease progression and severity [11,12]

With this systematic review, we can observe that the diaphragmatic ultrasound analysis in COPD patients is very versatile. It can be used in the follow-up of mechanically ventilated patients to monitor disease course or to predict weaning from MV; in the analysis of NIV tolerance and success; in outpatient clinics following the results of pulmonary rehabilitation processes; in diaphragmatic dysfunction analysis, present in the natural course of the disease; as well as in the follow-up and prognosis, by checking diaphragmatic thickness, thickening ratio, excursion time and mobility.

However, although diaphragmatic mobility measurements by ultrasound have proven to be a method of easy reproducibility and applicability, reference values in healthy individuals and methodology of applicability often differ in the literature [12,13,28]. Generally speaking, diaphragmatic mobility analysis is performed with a 3.5 Mhz curvilinear probe, the diaphragm is identified in B-mode, and then the diaphragmatic excursion measurement is best displayed in M-mode [12,21,22]. The mobility is usually observed in the patient's right thorax but can be performed bilaterally [10,14,30]. Spontaneous breathing in COPD patients has a 19-30 mm diaphragmatic mobility variability at rest [10–13], whereas, in deep inspiration, diaphragmatic mobility is around 27-69 mm [10,12,31]. Some studies have shown that the diaphragmatic mobility of COPD patients in spontaneous breathing is significantly lower when compared to control (healthy) patients [12,16,25].

Pulmonary rehabilitation programs appear to promote improvement in diaphragmatic dysfunction; patients undergoing these programs showed increased diaphragmatic mobility and thickness, even in more advanced cases of the disease [12,31]. Similarly, a study that performed stimulation techniques to improve diaphragmatic mobility through muscle stretching and release showed increased mobility in all assessed areas [30]. Diaphragmatic thickness and thickening fraction appear to estimate the inspiratory muscle workload, in COPD patients under spontaneous breathing, presents divergences in analyzing diaphragmatic dysfunction, no significant differences were observed in COPD patients and healthy patients regarding thickness measurements, as well as between different levels of disease severity, age, gender or BMI [24,26]. On the other hand, the studies have small sample sizes and different methods. In general, the analysis is performed with the linear probe and B-mode ultrasound; values of thickening fraction <20% and thickness <2.0 mm seem to present a worse prognosis [14,25]. Thickness and thickening ratio seem best related to the prognosis of mechanically ventilated COPD patients. Diaphragmatic dysfunction in these patients has been shown as a good predictor of MV failure, aid in weaning these patients, predictor of mortality, and length of hospital stay [14,18]. Likewise, lower diaphragmatic mobility was associated with failure to wean from MV, and diaphragmatic measurements performed with ultrasound seem better than predictors commonly used in these services, such as the rapid shallow breathing index, for ventilation weaning [22,31]. The need for tracheostomy can also be evaluated through diaphragmatic ultrasonography. Patients with diaphragmatic dysfunction present a higher risk of remaining on mechanical ventilation ($p = 0.03$) and thus a higher probability of requiring tracheostomy ($p=0.04$) [14]. Thus, measurements of diaphragmatic motion appear to be a powerful predictor of lung function and respiratory strength, thereby aiding in the prognosis of COPD patients.

LIMITATIONS

The review showed methodological limitations; most studies have relatively small and heterogeneous populations. Despite the good reproducibility of the method, most studies lack more detailed descriptions of the regions and analysis techniques and equipment used, patient position, unilateral or bilateral analysis of the diaphragm. The mobility, thickness and thickening fraction values diverge in different studies, thus requiring additional analyses of diaphragmatic dysfunction by ultrasound to determine reference values in this population.

CONCLUSIONS

Ultrasound is a helpful tool in analyzing diaphragmatic dysfunction in COPD patients, with versatility, so that it can be used in both high complexity and outpatient units. It appears to be a good prognostic predictor and a tool for analyzing the respiratory muscle condition in these patients. However, further studies are necessary to establish the reference values and technique standarts.

CONFLICTS OF INTEREST

None.

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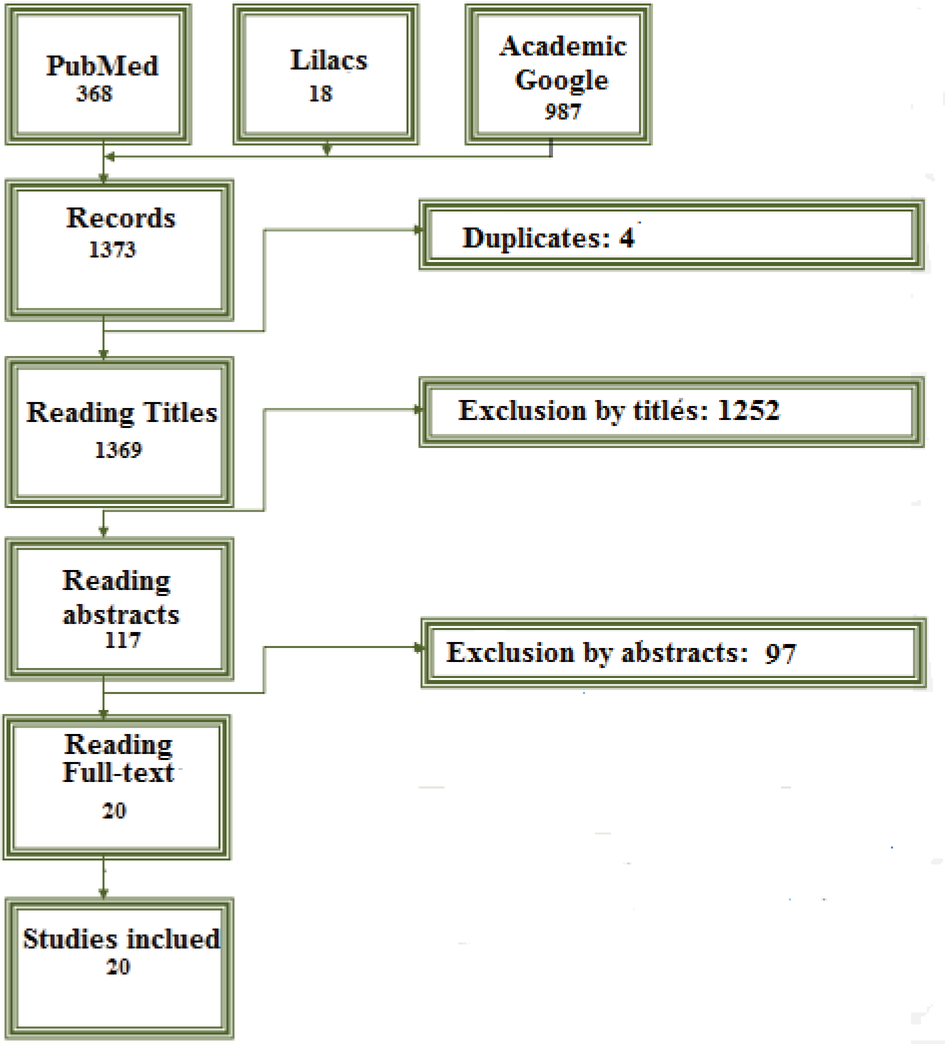

Figure 1 – Select studies.

ID, Year, Country	Desing e N	Methods	MainResults
1- Crimi, 2018, Italy.	Prospective Observational Study COPD (N=25) pre and post12 weeks of rehabilitation program (RP)	Ultrasound Sonoscape A6 e Logic Book GE, curved probe 2 a 6 and linear probe 6 a 15 MHz. Diaphragmatic Mobility (DM) M-mode andDiaphragmatic Thickness (DE) B-mode.	DM (median and 25º a 75º percentiles) preand post RP: Tidal volume (TV): 23 mm (16-17) vs. 27 mm (22-31), $p<0.001$. Deep inspiration (DI): 36 mm (25-53) vs. 50 mm (35-58), $p<0.001$. DE (median and 25º a 75º percentiles) pre and post RP: TV: 5 mm (3-6) vs. 4mm (3-4), p= 0.001. DI: 4 mm (3-5) vs. 3 mm (3-4), p= 0.027.
2- Corbellini, 2018, Italy.	Prospective Observational Study COPD moderateand severethatcompleted thepulmonary rehabilitation -PR (N=30) Healthyperson(N=16)	Ultrasound CX 50 portable, M-mode (no probe were mentioned) DM	DM (mean ±standard deviation) at COPD group: Resting breathing (RB): 2.09 ± 0.8cm DI: 4.75 ± 1.78cm DM (mean ±standard deviation) at healthy group: RB 1.27 ± 0.3 cm DI: 6.93 ± 1.15 cm There was an increase in DM in deep inspiration after PR in COPD patients (pre-PR 4.58 ± 1.83 cm vs post-PR 5.45 ± 1.56 cm), p=0.05. In COPD group, there was no difference between DM at resting breathing after RP (p= 0.4).
3- Nair, 2019, India.	Cross-sectional study COPD (n=20) Group A (n=10) diaphragmatic stretching Group B (n=10) diaphragmatic release technique	Ultrasound (neither model and probe type were mentioned) B-mode. DMat the clavicular midlineand at the right and left axillary midline	Diaphragmatic stretching technique: Clavicular midline:there was an increase in DM in both sides ($p<0,005$) Axillary midline: there was an increase at DM in the right side (p=0,003). There was no difference at the left side (p=0,31). Diaphragmatic release technique: Clavicular midline:there was an increase in DM in both sides (p =0,002) Axillary midline: there was an increase at DM in both sides ($p<0,001$)

COPD- Chronic Obstructive Pulmonary Disease, PR – Pulmonary rehabilitation, DM- diaphragmatic mobility, DE- Diaphragmatic thickness, DI – Deep inspiration, TV- Tidal volume, RB – Resting breathing.

Table I – Diaphragmatic mobility/diaphragmatic dysfunction in cardiopulmonary rehabilitation

ID, Year, Country	Desing e N	Methods	MainResults
1- Marchioni,2018, Italy.	Cross-sectional study Exacerbated COPD (N=75) requiring mechanical ventilation (MV)	Ultrasound GE Vivid 7, GE Healthcare, Little Chalfont,UK, B-mode, linear probe 7-12 MHz. Diaphragm Thickening Fraction (DTF) Diaphragmatic dysfunction (DD) was defined as a thickening ratio (RT)<20%.	Patients identified as DD on ultrasound had a higher risk of IMV failure (RR 4.4; p < 0.001). DD analysis proved to be a good predictor of NIV failure (p<0.0001), ICU mortality (p=0.007), hospital admission mortality (p=0.02), mortality within 90 days (p=0, 04), need for tracheostomy (p=0.04), more days of MV (p=0.03) and more time in hospital (p=0.0012).
2- Abbas, 2018, Egypt.	Observational Study COPD at MV ready for weaning (N=50)	UltrasoundSonoScape SSI-4000, SonoScape Medical Corp., Guangdong, China. M mode. DM as weaning criterion DD was defined as DM< 10mm.	DM (mean±standard deviation) ● Allpatients: 14.66 ± 4.01mm ● Successfulweaning: 16.57 ± 2.4mm ● Weaningfailure: 9.23 ± 2.42mm The DM measure (ROC 0.97 p=0.001) is superior to the rapid shallow breathing index (RSRI) (ROC 0.67 p=0.06) as a weaning criterion in patients with exacerbated COPD.
3- Zhang, 2020, China.	Prospective Observational Study COPDat MV (N=37)	Ultrasound (no model mentioned), curved probe 2-5MHz. DMduring spontaneous breathing test (EBT) at 0, 5 and 30 minutes.	A cut-off value ofDM >1.72 cmandΔDM 30–5min > 0.6 cm were associated with a succeed extubation. Sensibility = 76% and 84%; and specificity= 76% and 83.3%, respectively.
4- Anterona, 2017, Italy.	Pilot Study Prospective Observational Cohort Exacerbated COPD (N=41)	Ultrasound GE vivid 7, B mode, linear probe 7-12Mhz. DD defined as DTF < 20%.	Patients that failed at VNI weaninghadDD ($p < 0.001$ e $R^2 = 0.27$). DD is associated withhigher ICU permanency (p=0.02, R^2= 0.13); long MV (P = 0.023, $R^2 = 0.15$); and tracheostomy need (p = 0.006, $R^2 = 0.20$).
5- Fayed, 2016, Egypt.	Prospective Observational Exacerbated COPDat MV(N= 60)	Ultrasound DP-3300, Shenzhen mindray, curved probe 3.5 -5Mhz, B- mode and M- mode. DM DD was defined as DM < 1 cm	DD group: Longer weaning time from MV [96h (84-120) vs 36h (24-48), p<0.001]. Longer MV time [192h (168-204) vs 72 (72-72), p<0.001]. More days in the ICU [10.0 days (9-13) vs 5.0 (4-5), p<0.001]. More days of hospital stay [12.0 days (12-15.5) vs 6.0 (5-6), p<001].

6- Abo-Alyzeid, 2019, Egypt.	Prospective Observational COPD ready for MV weaning (N=104)	No ultrasound or probe were mentioned. M mode. DM, DTF Evaluation of two predictor indices Diaphragmatic rapid and shallow breathing index (D-RSBI=RR/diaphragmatic displacement) Rapid and shallow breathing index (RSBI=RR / tidal volume) Group A = successful weaning Group B= weaning failure	DM (mean ±standard deviation): group A: 23.1 ± 4.2 mm vs. group B: 16.0 ± 5.4 mm (p<0,001) DTF (mean ±standard deviation): group A: 23.2 ± 3.9 % vs group B: 17.4 ± 6.4 % (p<0,001) RSBI ● Sensibility: 77,8% ● Specificity: 70,9% D-RSBI ● Sensibility: 83,3% ● Specificity: 90,7% D-RSBI is more sensitive and specific than RSBI for predicting weaning failure (p< 0.001).
7- Lim, 2019, South Korea.	Prospective Observational COPD at acute exacerbation, men (N=10)	UltrasoundLogic E, GE,Linearprobe 4-10 MHz. DM e DTF Measurements taken 72 hours after exacerbation (beginning) and after symptoms recovery.	DTF was higher after symptoms recovery: 80.1 ± 104.9 vs 159.5 ± 224mm. p=0.01. There was no difference between DM at the beginning of the exacerbation and after symptoms recovery (22 ± 6mm vs 23 ± 12 mm; p = 0.75) There was a strong correlation between DTF in the steady state and the predicted value of baseline FEV1% (r = 0.89, p = 0.017). There was no correlation between DTF and time to exacerbation.

COPD- Chronic Obstructive Pulmonary Disease, DM- diaphragmatic mobility, DTF- Diaphragm Thickening Fraction, DD- Diaphragmatic dysfunction, RT- thickening ratio, IMV – invasive mechanical ventilation, NIV- non invasive ventilation, ICU- intensive care unit, MV- mechanical ventilation, RSRI- rapid shallow breathing index, EBT- spontaneous breathing test, D-RSRI - Diaphragmatic rapid and shallow breathing index.

Table II- Diaphragmatic mobility/diaphragmatic dysfunction and Mechanical Ventilation

ID, Year, Country	Desing e N	Methods	MainResults
1-Scheibeet, 2015, Germany.	Case control CPOD (N=60) GOLD II – N=20 GOLD III – N=20 GOLD IV – N=20 Healthypersons (N=20)	Ultrasound Sono MR, EUB-7500 HV, curved probe 3.5MHz. DM sitting and lying position.	DM sitting and lying position: GOLD II 43mm e 46 mm GOLD III 30 mm e 37mm GOLD IV 25mm e 31mm Controle 65mm e 68mm Strong correlation between the measurements of the two methods sitting and lying down r=0.85. Strong correlationof DM and FEV1 r=0.83.
2- Kang, 2011, Korea.	Prospective Observational Study COPD ATS (N=37)	Ultrasound ALOKA KEC-620, B-mode, curved probe 3,5 MHz. DM, lying position.	DM (mean ± standard deviation): 19.8 ±7.5 mm. DM correlated with airway obstruction (FEV1, r = 0.415, p = 0.011); pulmonary hyperinflation (RV r=0.501 p=0.02; CPT r= -0.28 p= 0.03). Negative correlation with PaCO2 r= -0.028 p= 0.03.
3- Paulin, 2007, Brazil.	Case control CPOD ATS (N=54) Healthypersons(N=20)	Ultrasound LOGIC 500 GE, GE Medical Systems Milwaukee, WI Modo B, curved probe 3,5 MHz. DM, lying position.	COPD patients had lower MD than controls (mean ± standard deviation) (36.27 ± 10.96 mm vs. 46.33 ± 9.46 mm, p<0.05). DM showed a linear correlation with the distance covered in the 6MWT (r = 0.38; p = 0.005) and a negative correlation with dyspnea (modified Borg scale) (r = 0.36; p = 0.007).
4- Corbellini, 2018, Italy.	Prospective Observational Study COPD GOLD (N= 46) Healthypersons(N=16)	Ultrasound M-mode, Philips CX50, curved probe. DM between Resting Breathing and Deep Inspiration (PI).	DM (mean ± standard deviation) at rest breathing: 1.27 ± 0.3 cm in healthy subjects vs 2.09 ± 0.8 in COPD. DM (mean ± standard deviation) in deep inspiration: 6.93 ± 1.15 cm healthy and 4.75 ± 1.58 cm COPD. There was a difference in DM at rest in the subgroups of COPD vs in the subgroups: GOLD 2 (p<0.01), GOLD 3 (p=0.02), GOLD 4 (p<0.01). In IP GOLD 2 (p=0.05), GOLD 3 (p<0.01) and GOLD 4 (p=0.02). Rest DM and PI correlated with FEV1 (r= -0.74)

5- Elkabany, 2020. Egypt.	Cross-sectional study CPOD GOLD (N= 50)	Ultrasound Sonoscape A8 Medical Systems, Shenzhen, China, curved probe 3-5 MHz, B and M-mode. DM, lying position.	There was no difference in the means of measurements made by the operators (p=0.330). DM (mean ± standard deviation) at rest operator 1 2.82±1.08 vs 2.81±1.07 operator 2, p=0.28. MD during operator 1 sniffing test 4.58±1.16 vs 4.59±1.15 p= 0.21. MD in deep inspiration operator 1 3.19±0.94 vs 3.25±0.99 operator 2 p= 0.33.
6- Qutb, 2020. Egypt.	Case control COPD GOLD (N=100) Healthypersons(N=100)	Ultrasound SSI6000 Sonoscape, curved transdutor 3,5MHz, B and M-mode. DM, semi reclining position. M-mode index of obstruction (MIO)= DM at 1s/end-expiration DM.	DM (mean ± standard deviation) at maximum expiration: 4.82 ± 1.55 cm (cases)/ 5.72 ± 1.57 cm (controls), p<0.001. DM in forced expiration in 1s: 4.27 ± 1.49cm (cases) / 5.36 ± 1.67cm (controls) p<0.001. Lower MIO in COPD (88.46 ± 9.92 vs 93.37 ± 11.15, p = 0.001). Positive correlation with FEV1/FVC p=0.007.
7- Baria, 2014, USA.	Case control COPD ATS (N=50) Healthypersons (N=150)	UltrasoundLogiq E, GE, linear probe 8 a 13 MHz. Thickness of the diaphragm (DE) and Thickening Ratio. Lying position.	There was no significant difference in diaphragmatic thickness or thickness ratio within or between the COPD or healthy control groups, with the exception of the subgroup with a severe entrapment (residual volume >200%), without which the thickness ratio was higher at left (p = 0.02), compared with the control group or with the entire COPD group.
8 -Ogan, 2019, Turkey.	Case control COPD GOLD (n=34) Healthypersons(n=34)	Ultrasound Voluson General Eletric Image, linear probe (does not mention MHz and mode). DE during tidal volume and maximal inspiration. Lying position.	There was no correlation between the DE of COPD patients and the control group, both in resting (p=0.64) and deep breathing (p=0.90). There was no significant difference between DE and disease severity (p=0.41) number of exacerbations (p=0.88) and modified Medical Research Council (mMRC) (p=0.66).

9- Cimsit, 2016. Turkey.	Cross-sectional study COPD (N=53)	Ultrasound Logiq E9, GE Healthcare, linear probe 9-15 MHz, B-mode. DE, lying position.	There was no difference in DE in relation to sex, age and BMI (p>0.05). There was a moderate correlation between DE and FEV1 in patients with mild COPD (r = 0.62, p = 0.017). There was no statistically significant difference in DE between GOLD A, B and C patients.
10- Ramachandran, 2020. India.	Case control COPD (N=20) healthy persons (N= 18)	Ultrasound Sonosite S-ICU, linear probe, 8-16 MHz and curved probe 3,5 MHz B and M-mode. DM, reclining 45°. DE	DM (mean ± standard deviation) in COPD vs control (5.35 ± 2.8 cm vs. 7 ± 2.6 cm) p>0.05. DE (mean ± standard deviation) COPD had less diaphragmatic thickness than controls (1.8 ± 0.5 mm vs. 2.2 ± 0.6 mm; p = 0.005). There was no correlation between FEV1 and diaphragmatic measurements (p=0.2).

COPD- Chronic Obstructive Pulmonary Disease, PR – Pulmonary rehabilitation, DM- diaphragmatic mobility, DE- Diaphragmatic thickness, DI – Deep inspiration, TV- Tidal volume, RB – Resting breathing,GOLD -Global Initiative For Chronic Obstructive *Pulmonary* Disease, FEV1- first second of forced expiration, ATS- American Thoracic Society, CPT - total lung capacity, RV – residual volume.

Table III - Diaphragmatic mobility/diaphragmatic dysfunction and Disease Severity

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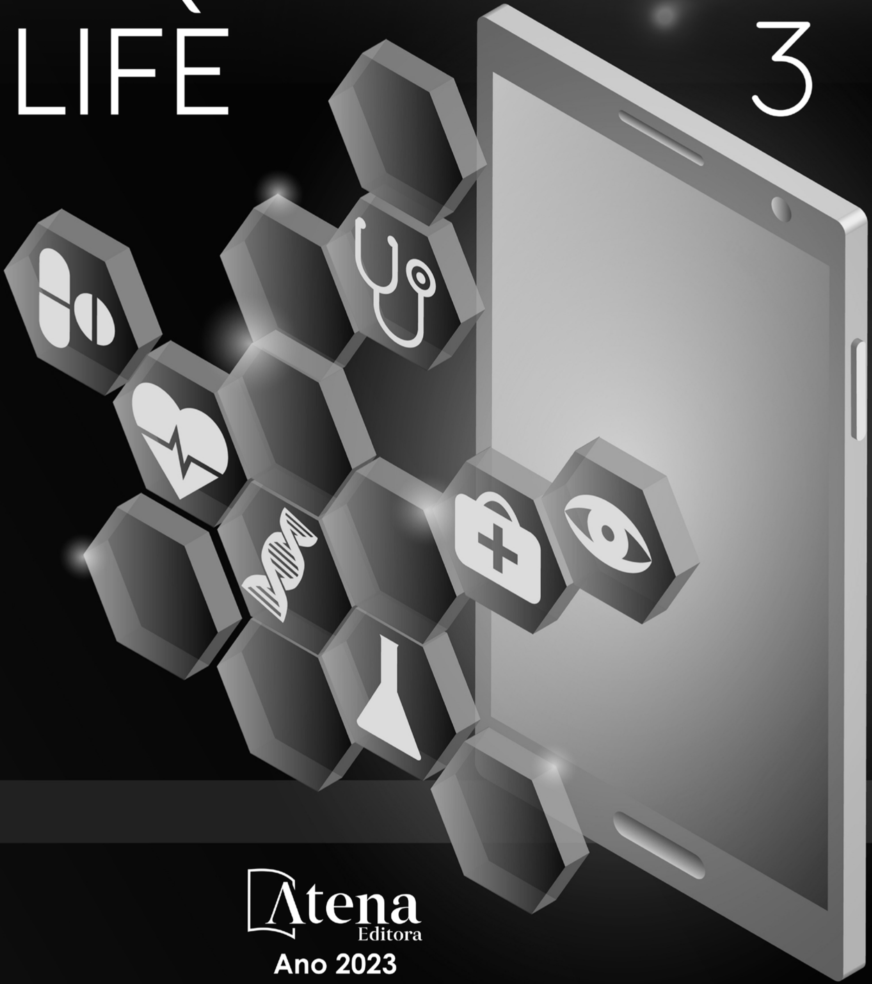

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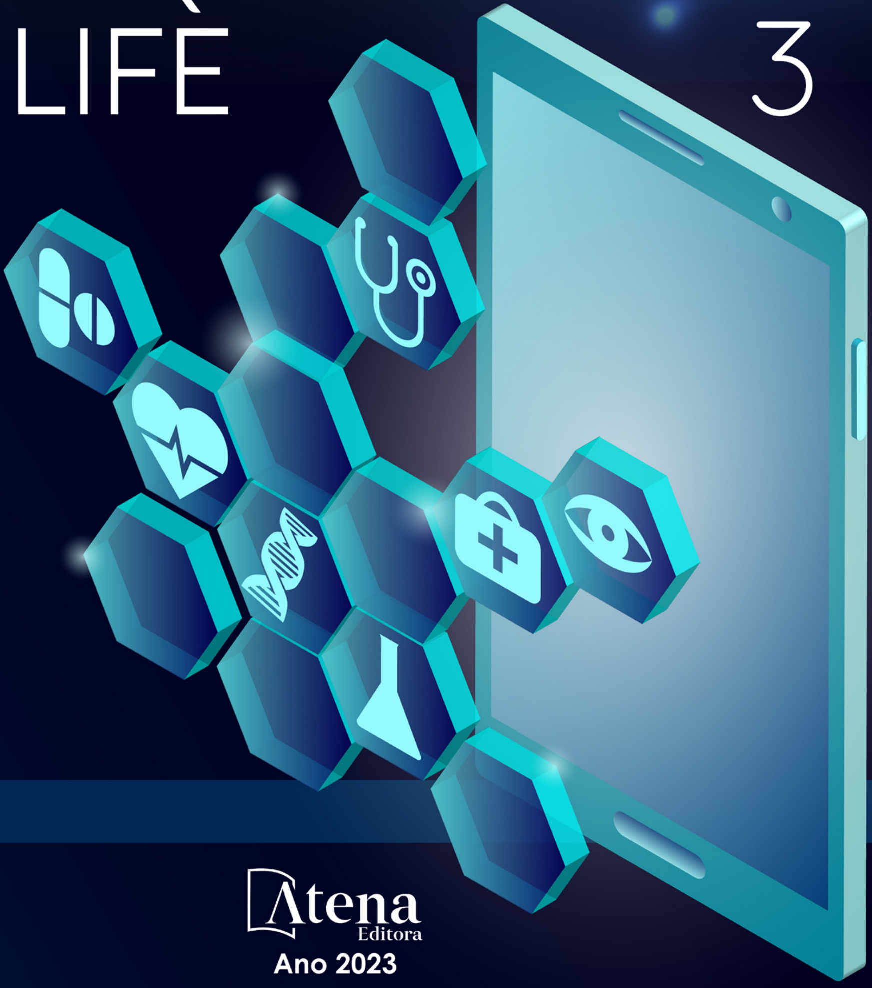

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