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The Prevalence of Dysfunctional Breathing Symptoms is Similar Among Amateur Choir Singers and Non-Singers: A Cross-Sectional Comparative Study

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Abbreviations

ASBL: Non-Profit Association

BHT: Breath-Holding Time

BH t1: Breath-Holding Time 1

BH t2: Breath-Holding Time 2

BMI: Body Mass Index

BPAT: Breathing Pattern Assessment Tool

BPD: Breathing Pattern Disorder

CI: Confidence Interval

COPD: Chronic Obstructive Pulmonary Disease

CRD: Chronic Respiratory Diseases

DB: Dysfunctional Breathing

GCP: Good Clinical Practice

HADS: Hospital Anxiety and Depression Scale

HADS-A: Hospital Anxiety and Depression Scale - Anxiety Subscale

HVS: Hyperventilation Syndrome

MARM: Manual Assessment of Respiratory Motion

MCID: Minimal Clinically Important Difference

MDP: Multidimensional Dyspnea Profile

MDP A1: Multidimensional Dyspnea Profile - Affective Dimension 1

MDP A2: Multidimensional Dyspnea Profile - Affective Dimension 2

MDP SQ: Multidimensional Dyspnea Profile - Sensory Quality

MPA: Music Performance Anxiety

n (or N): number

N/A: Not Applicable

NQ: Nijmegen Questionnaire

N.S.: Non-Significant

p: p-value

P: Proportion

PaCO₂: Arterial Blood Partial Pressure of Carbon Dioxide

pH: potential of Hydrogen

QoL: Quality of Life

RCT: Randomized Controlled Trial

REDCap: Research Electronic Data Capture

SD: Standard Deviation

UCL: Université Catholique de Louvain

α : Significance level

ρ : Spearman's Rho

1. INTRODUCTION

1.1 Dysfunctional Breathing

Dysfunctional Breathing (DB) is a condition characterized by alterations in the breathing pattern, with the primary symptom being dyspnea in the absence of respiratory or cardiac pathology, or unexplained by such pathology ('*disproportionate breathlessness*', Watson et al., 2021). This condition is associated with an impaired Quality of Life (QoL) (Chenivesse et al., 2014). The functional thoracic DB is described as Breathing Pattern Disorder (BPD), the most well-known form is Hyperventilation Syndrome (HVS) (Boulding et al., 2016; Simpson et al., 2019). The definition of DB remains a topic of discussion in the literature, and there is no established diagnostic test or gold-standard for its identification (Boulding et al., 2016; Depiazzi & Everard, 2016; Hagman et al., 2008). Several authors describe DB as a condition involving three interdependent dimensions: biochemical, biomechanical, and psychophysiological. (i) The biochemical dimension is characterized by a decrease in PaCO₂ and an increase in pH caused by hyperventilation. (ii) The biomechanical dimension refers to alterations in the breathing pattern and motor control of the respiratory muscles. (iii) The psychophysiological component corresponds to the influence of psychosocial factors on symptomatology (Barker et al., 2020; Courtney, 2017; Kiesel et al., 2017).

Prevalence rates reported in the literature primarily concern HVS, with a prevalence of 6 to 10% in the general population (Boulding et al., 2016). However, the prevalence may be underestimated, as DB is underdiagnosed and frequently confused with asthma (Barker et al., 2018; Byrne et al., 2023; Hagman et al., 2008, 2011). DB is also associated with various respiratory conditions (*secondary DB*). Indeed, higher prevalence rates are reported in patients with underlying respiratory conditions than in the general population (Barker & Everard, 2015). Among individuals with asthma, this prevalence increases from 29% to 64% (Agache et al., 2012; Courtney, 2017; Thomas et al., 2001), and within Chronic Obstructive Pulmonary Disease (COPD) patients, the prevalence

was estimated at 47% (Law et al., 2018). Furthermore, the COVID-19 pandemic has led to an increase in the prevalence of DB. Persistent post-COVID-19 symptoms often cause dyspnea, anxiety, and impaired QoL (Philip et al., 2022), all of which are linked to DB. Similarly, the pandemic has heightened anxiety and concern about health and respiratory sensations, which promotes the onset of DB (Koniukhovskaia et al., 2021; Steinmann et al., 2023). Among patients suffering from persistent post-COVID-19 symptoms, the prevalence of DB is 29.4% (Frésard et al., 2022), with 49% of them having a positive score on the Nijmegen Questionnaire (score >23/64), which assesses DB symptoms (Bouteleux et al., 2021). Additionally, during the pandemic, Steinmann et al. (2023) found that 24% of healthy subjects without a history of COVID-19 had a positive score on the Nijmegen Questionnaire (NQ), which is significantly higher than previously reported figures in the literature.

1.2 Background

A current shift in healthcare policy emphasizes non-medical interventions such as Art-in-Health, which can be implemented outside formal healthcare settings for individuals with chronic conditions (Bowden et al., 2020; Fancourt & Finn, 2019; Philip et al., 2020). Music therapy with singing-based activities can contribute to disease management within the biopsychosocial framework (Fancourt & Finn, 2019; Gick & Nicol, 2016; Philip et al., 2019). Indeed, it has been studied in various respiratory conditions such as asthma, COPD, and COVID-19 (Lewis et al., 2016; Loewy et al., 2021; McNamara et al., 2017; Philip et al., 2020) and has demonstrated numerous positive physical, psychological, and social effects (Gick & Nicol, 2016; Lewis et al., 2016). Moreover, singing could also address the different aspects of dyspnea (*sensory, affective, and the resulting impact*) (Lord et al., 2010).

- Physical effects

Singing requires the control and coordination of respiratory muscles to modulate airflow (Gick & Nicol, 2016; Irons et al., 2010; Kang et al., 2018; Lewis et al., 2021; McNamara et al., 2017)¹. Trained singers tend to exhibit a more abdominal

¹ which targets the sensory component of dyspnea (Lord et al., 2010)

breathing pattern, with a greater abdominal contribution to total lung volume during speech and singing compared to untrained individuals (Salomoni et al., 2016). Furthermore, Engen (2005) demonstrated that singing training led to a change in the resting breathing pattern in COPD patients, from a thoracic-dominant to an abdominal ("diaphragmatic") dominant pattern. These skills are part of the Breathing Training protocols recommended for treating DB, which have shown beneficial effects on QoL (Courtney et al., 2019; Hagman et al., 2011; Thomas et al., 2003; Vidotto et al., 2018). Singing in a standing position has been shown to have similar physiological effects to moderate-intensity physical activity (Philip et al., 2021). Additionally, singing helps to reduce the perception of dyspnea (Canga et al., 2015; Daugherty, 2013; Kaasgaard, Rasmussen, Løkke, et al., 2022)² as well as exercise-induced breathlessness (Philip et al., 2022)³. Singing interventions have also resulted in a reduced number of general practitioner visits among COPD patients (Lewis et al., 2018) and decreased emergency room visits and hospitalizations among asthma patients (Loewy et al., 2021)⁴.

- **Psychological effects**

Singing interventions in patients with respiratory diseases consistently improve well-being and QoL (Daugherty, 2013; Gick & Daugherty, 2015; Lewis et al., 2016; Loewy et al., 2021; Lord et al., 2010, 2012; Philip et al., 2019; Philip et al., 2021; Reagon et al., 2016)⁵. They have also shown positive effects on anxiety and better stress management (Daugherty, 2013; Fancourt & Finn, 2019; Kaasgaard, Rasmussen, Løkke, et al., 2022; Lord et al., 2010; K. Philip et al., 2019). Furthermore, singing is a positive experience associated with breathing. It allows patients to explore breathing sensations in an enjoyable way and may improve their sense of control over their breathing (Courtney, 2017; Lewis et al., 2016). This may help to break the vicious cycle of anxiety and dyspnea, leading to a '*desensitization*' of breathlessness (Herer, 2013; Martinez, 2008)⁶.

² which targets the sensory component of dyspnea

³ which targets the impact of dyspnea

⁴ *Ibidem.*

⁵ *Ibidem.*

⁶ which targets the affective component of dyspnea (Lord et al., 2010)

- **Social effects**

Breathlessness and Chronic Respiratory Diseases (CRD) are known to induce social isolation (Lewis et al., 2016; Philip et al., 2019; Reeves et al., 2014), which negatively impacts health. A lack of social involvement worsens CRD symptoms (Lewis et al., 2016; Philip et al., 2020), reduces patient self-management and healthy behaviors (Reeves et al., 2014), increases perceived everyday life stress (Cacioppo & Hawkley, 2003), and leads to a restriction of participation (Philip et al., 2019). Additionally, choir singing is a group activity that increases social networks (Lewis et al., 2016)⁷. Qualitative data on singing-based interventions indicate that choir singing enhances social support, relatedness, and a sense of belonging (McNamara et al., 2017; McNaughton et al., 2016; Reagon et al., 2016; Stewart & Lonsdale, 2016). This can have a protective effect on the health of patients with chronic conditions by increasing their self-efficacy and reducing their perceived stress (Reeves et al., 2014).

While breathing therapy through singing appears to be beneficial, there is still a lack of reliable evidence and controlled studies (Gick & Nicol, 2016; Kang et al., 2018; Lewis et al., 2016, 2018; Sliwka et al., 2012). Furthermore, singing might have a negative impact on DB symptoms. Indeed, musicians experience more symptoms than the general population (Widmer et al., 1997), and singers and wind players report more respiratory complaints on the NQ than other musicians. However, this increase in respiratory symptoms could be explained by a heightened awareness of their breathing, as singers and wind players focus more on respiratory functions, which are essential for their performance, compared to other musicians (Studer et al., 2011). There is also data showing that singing might increase breathlessness among patients with respiratory conditions, depending on the activity (Barker et al., 2018; Philip et al., 2021). Furthermore, group singing is described as increasing social well-being (Gick & Nicol, 2016), whereas solo singing can elevate stress levels (Daugherty, 2013), which might heighten anxiety related to respiratory sensations.

Thus, amateur choir singing could either worsen symptoms associated with DB, particularly respiratory symptoms, or act as a protective factor by disrupting

⁷ which targets the impact of dyspnea

the self-perpetuating cycle of anxiety and dyspnea, thereby reducing the overall impact of the condition. No study has yet assessed singing in the treatment of DB, except for an RCT (Randomized Controlled Trial) protocol published by Lewis et al., in 2022, aiming to compare the effects of traditional Breathing Therapy with music therapist-led breathing exercises, including solo singing. Therefore, the potential effects of amateur singing or choir singing on DB symptoms or on breathing pattern remain uncertain.

1.3 Objectives

The primary objective of this study is to assess the prevalence of respiratory and non-respiratory symptoms associated with DB in a group of amateur choir singers and compare these findings with a group of non-singers. Our secondary objective is to investigate the correlations between the results of different measurement tools for DB aspects and the socio-demographic characteristics of the participants. To achieve this, we conducted a screening of these various aspects using (i) the NQ to assess respiratory and non-respiratory symptoms associated with DB, (ii) the Breathing Pattern Assessment Tool (BPAT) for the biomechanical component, (iii) the anxiety-related questions from the Hospital Anxiety and Depression Scale (HADS) for the psychological aspect, and (iv) the Multidimensional Dyspnea Profile (MDP) for breathlessness. We also evaluated the inspiratory Breath-Holding Time (BHT), a test of breathing function (Courtney, van Dixhoorn, et al., 2011) which is reduced in patients with DB (Jack et al., 2003; Kopitović & Mirić, 2023). In this study, we did not evaluate the biochemical and social aspects (related to QoL).

2. METHOD

2.1 Design and Settings

To address our research question, we conducted a cross-sectional comparative study following the STROBE checklist. The experimental procedure was approved by the local Ethics Committee of Cliniques Universitaires Saint-Luc (UCL, Belgium) 2023/12DEC/508 (Appendix A) and followed the Good Clinical Practice (GCP) guidelines and the Declaration of Helsinki principles. All participants received an information document and completed a consent form prior to any measurements. The measurements were conducted in Belgium (Walloon and Brussels regions) during March and April 2024.

2.2 Participants

This study included two groups of participants, one group of individuals engaged in amateur choir singing and another group who do not participate in such activities. The participants had to be adults aged 18 to 80 years, of either gender, fluent in French, who do not have a diagnosis of neurological disease affecting the respiratory system and declaring that they were not pregnant. In the control group, duplicates and incomplete forms were excluded; no exclusion criteria were applied to the choir group. For the choir group, participants were recruited through choirmasters from several non-profit organizations (ASBL) in the Wallonia-Brussels Federation. For the control group, recruitment was conducted online through postings providing access to the questionnaire on various social media platforms and via word of mouth. The participants in both groups were matched by age and sex at a 1:2 ratio (control:choir).

2.3 Outcomes measures and assessment

2.3.1 Primary Outcome

The Nijmegen Questionnaire (NQ)

The NQ consists of 16 questions, each evaluating a specific symptom, and scored on a five-point ordinal scale based on the frequency of symptom occurrence (0=never; 4=very often). The total score ranges from 0 to 64, with scores above 23 indicating a higher risk of DB. This cutoff score has demonstrated a sensitivity of 91% and a specificity of 95% for HVS screening (Van Dixhoorn & Duivenvoorden, 1985). The respiratory symptoms subscale includes the items: 'shortness of breath,' 'tightness in the chest,' 'difficulty breathing deeply,' and 'fast or deep breathing' (Studer et al., 2011; Van Dixhoorn & Duivenvoorden, 1985). This subscale's score ranges from 0 to 16. Courtney et al. (2011) defined a cutoff score of 5 as indicative of an abnormal result. In this study, we used the French version of the NQ (Appendix B).

2.3.2 Secondary Outcomes

The Hospital Anxiety and Depression Scale (HADS)

In this study, we assessed only the anxiety subscale score of the HADS (HADS-A). This subscale consists of 7 items that evaluate symptoms indicative of a state of generalized anxiety. Each item is scored on a four-point ordinal scale (0=absence of symptom; 3=extreme presence). The total score for the HADS-A subscale ranges from 0 to 21. A score of ≤ 7 indicates the absence of anxiety symptoms; a score between 8 and 10 is considered indicative of dubious symptomatology; and a score of ≥ 11 signifies the presence of significant anxiety symptoms. A score ≥ 8 on the HADS-A subscale showed a sensitivity of 90% and a specificity of 78% (Bjelland et al., 2002). In this study, we used the French version of the HADS-A (Appendix C).

The Multidimensional Dyspnea Profile (MDP)

The MDP is a multidimensional scale that assesses both the sensory and affective components of dyspnea. It comprises three subscales: the A1 scale (MDP A1) and the A2 scale (MDP A2) evaluate the affective component of dyspnea, specifically

related to breathing discomfort and the emotional response to dyspnea, respectively, while the Sensory Quality scale (MDP SQ) assesses sensory perceptions. The MDP is valid and responsive, with a Cronbach's α ranging from 0.82 to 0.95 (Meek et al., 2012). In this study, we used the French version of the MDP (Appendix D).

The Breathing Pattern Assessment Tool (BPAT)

The BPAT is a clinician-led evaluation of the breathing pattern (Appendix E). It has been validated for screening BPD in patients with asthma or unexplained dyspnea (Todd et al., 2018). During this assessment, the participant remains seated in a chair with back support while the clinician evaluates 7 items corresponding to different components of the breathing pattern. These items include abdominal and chest wall movements, inspiratory and expiratory sounds, sighing or other signs of air hunger, nasal versus oral breathing, respiratory rate, and the rhythmicity of the breathing pattern. The total score ranges from 0 to 14, with each item scored from 0 to 2. A higher score indicates a greater likelihood of breathing pattern disturbance. A positive screening for BPD is defined by a total score of ≥ 4 with a sensitivity of 92% and a specificity of 75% (Bondarenko & Holland, 2023; Todd et al., 2018).

The Breath-Holding Time (BHT)

The inspiratory Breath-Holding Time was measured at rest, with participants in a seated position with back support. They were instructed to hold their breath for as long as possible after a maximal expiration to residual volume, followed by a maximal inspiration to total lung capacity. Participants performed one breath-holding maneuver during which two time points were measured: the first time corresponds to the onset of the first sensations of breathing discomfort (BH t1), and the second time marks the end of the test at the appearance of the first involuntary respiratory movements or after a spontaneous cessation by the participant without the occurrence of involuntary respiratory movements (BH t2). To measure BH t1, participants were instructed to raise their hand at the first signs of breathing discomfort. During this test, no encouragement was provided to the participants. Under similar conditions, Jack et al. (2003) reported that healthy

subjects had a mean maximal BHT (equivalent to BH t2) of 63 ± 31 seconds (\pm SD), whereas patients with DB had a mean maximal BHT of 20.4 ± 12 seconds (\pm SD).

Complementary measures

Participants also completed an informational questionnaire designed to collect socio-demographic data that may influence the results of the various measurement tools (Appendix F). The collected information included: age, BMI, professional category, tobacco use, and the presence of a respiratory, cardiac, or psychiatric condition diagnosis. Participants in the choir singing group were additionally required to provide details on the number of rehearsals they attend each month and the duration of their involvement in this activity. Participants in the control group were asked whether they engage in any recreational group activities at least once a week.

2.4 Data Collection

Choir group

The experimentation was conducted at the choir's rehearsal venues. Participants first completed a questionnaire in the following order: the informational questionnaire, the NQ, the HADS-A, and the MDP. They then performed two additional tests: the BPAT and the BHT. The examination conditions were standardized; participants were assessed by the same examiner and received the same instructions. They were not informed about the content of the BPAT, the purpose of the different questionnaires (except for the MDP), or the existence of a control group.

Control group

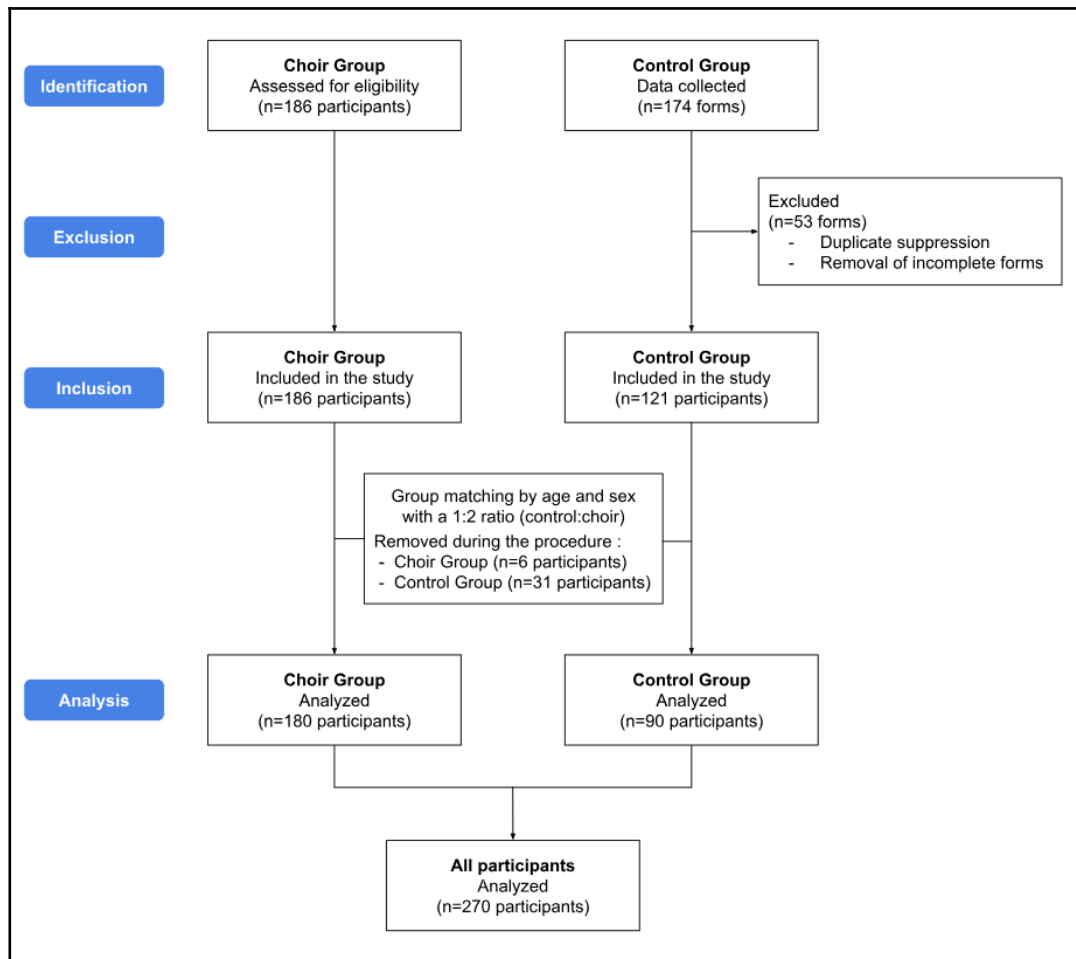
Participants completed the same questionnaire as the choir group online. Data were collected using REDCap (Research Electronic Data Capture) electronic data capture tools hosted at Cliniques Universitaires Saint Luc (Harris et al., 2009, 2019).

2.5 Data Analysis

Data were analyzed using SPSS version 27.0 (IBM Software, Armonk, NY: IBM Corp). Missing data were treated as such, and statistical analyses were based on observations with complete data. For descriptive statistics, quantitative variables were expressed as means (standard deviations) or medians (25th-75th percentile), and qualitative variables as proportions and percentages. Data normality was assumed based on the law of large numbers or assessed with Shapiro-Wilk tests, homoscedasticity was checked using Levene's tests. For quantitative variables with a normal distribution, comparisons between the two groups were performed using unpaired two-tailed t-tests, and paired t-tests were used for within-subject comparisons. When normality was not confirmed, non-parametric Mann-Whitney tests were performed. For qualitative variables, comparisons were made using Chi-Square tests or Fisher's exact tests depending on the number of occurrences within contingency tables. The null hypothesis assumed no difference between the groups. Additionally, correlation analyses were performed using Pearson correlation coefficients for continuous variables and Spearman's Rho for discrete variables. Relationships between qualitative variables were analyzed using Chi-Square tests of independence. The significance level was set at 5% ($\alpha=0.05$).

3. RESULTS

Figure 1. STROBE flow diagram



3.1 Participants

In total, data from 270 participants were analyzed, comprising 180 in the choir group (Appendix G) and 90 in the control group (Figure 1). Both groups had a similar mean age (mean difference=1.33 years, $p=0.515$) and sex repartition (proportion of females=67.8% in both groups, $p=1.000$). The sociodemographic characteristics are presented in Table 1. There was no difference in the proportion of professional categories between groups ($p=0.602$); the majority of participants (44.4% of the choir group and 41.1% of the control group) belonged to higher professional categories (e.g., executives, senior managers, intellectual and scientific professions). Additionally, although the mean BMI was similar between

the two groups ($p=0.141$), there were more obese participants in the choir group than in the control group ($P: 16.1\%$ vs. 5.6% , $p=0.014$).

Table 1. *Socio-Demographic Characteristics of Participants*

Characteristics	Choir Group (n=180)	Control Group (n=90)	Comparison
Age (years)	42.4 (± 16.0)	41.1 (± 15.2)	$p=0.515$
Sex Female/Male	122/58	61/29	$p=1.000$
BMI (kg/m ²)	24.6 (± 5.0)	23.8 (± 3.7)	$p=0.141$
Tobacco use [n (%)]	10 (5.6%)	18 (20%)	$p<0.001^{***}$
Pathologies [n (%)]			
Respiratory	26 (14.4%)	12 (13.3%)	$p=0.805$
Cardiovascular	19 (10.6%)	6 (6.7%)	$p=0.299$
Psychiatric	11 (6.1%)	2 (2.2%)	$p=0.231$
Participation in choir singing			
Duration (month)	149.7 (± 169.1) ^a	N/A	N/A
Monthly rehearsal frequency	4 (4-5) ^b	N/A	N/A
Participation in a leisure group activity [n (%)]	N/A	53 (58.9%)	N/A

Data are presented as Mean (\pm Standard Deviation) or Median (25th-75th percentile) ; ^a 1 missing value ; ^b 2 missing values ; n: number of participants ; BMI: Body Mass Index ; N/A: Not Applicable ; p: p-value ; *** $p<0.001$

3.2 Outcomes Results and Between-group Comparisons

The results from DB assessment screening tools are shown in Table 2.

Nijmegen Questionnaire

No differences were found between the two groups regarding the NQ results ($p=0.501$) or the respiratory symptoms subscale score ($p=0.096$).

HADS-A

The mean anxiety score and the proportion of symptoms certainty categories were similar between the two groups ($p=0.693$ and $p=0.476$, respectively).

MDP

Regarding dyspnea, the choir group had a higher mean score on the MDP SQ compared to the control group (mean difference=2.25, 95% CI [0.375 to 4.120], $p=0.019$). In contrast, the control group had a higher mean score on the MDP A2 than the choir group (mean difference=-3.43, 95% CI [-5.959 to -0.907], $p=0.008$). For the numerical subscale SQ, the items 'Air Hunger' and 'Chest Tightness' were higher in the choir group compared to the control group ($p<0.001$, $p=0.009$, respectively) (Figure 2.A). In the numerical subscale A2, the control group scored higher than the choir group for the items 'Depressed' ($p=0.014$), 'Frustrated' ($p=0.006$) and 'Angry' ($p=0.003$) (Figure 2.B). No difference was observed for the A1 subscale ($p=0.239$).

Within the whole sample, males had higher scores than females across all three MDP subscales. For the A1 subscale, males had a mean score of 2.50 (\pm SD) ± 2.32) compared to 0.91 (± 1.45) for females, with a mean difference of -1.59 (95% CI [-2.13 to -1.05], $p<0.001$). On the SQ subscale, males had a mean score of 9.76 (± 9.71) versus 3.08 (± 5.73) for females, with a mean difference of -6.68 (95% CI [-8.92 to -4.44], $p<0.001$). For the A2 subscale, males had a mean score of 10.16 (± 10.84) compared to 5.77 (± 9.30) for females, with a mean difference of -4.39 (95% CI [-7.71 to -1.71], $p=0.001$). Additionally, smokers had higher mean scores on the A1 subscale compared to non-smokers (2.22 ± 2.44 vs. 1.33 ± 1.84 , $p=0.035$), while no differences were observed for the SQ and A2 subscales ($p=0.060$ and $p=0.124$, respectively). Moreover, the mean scores for the three

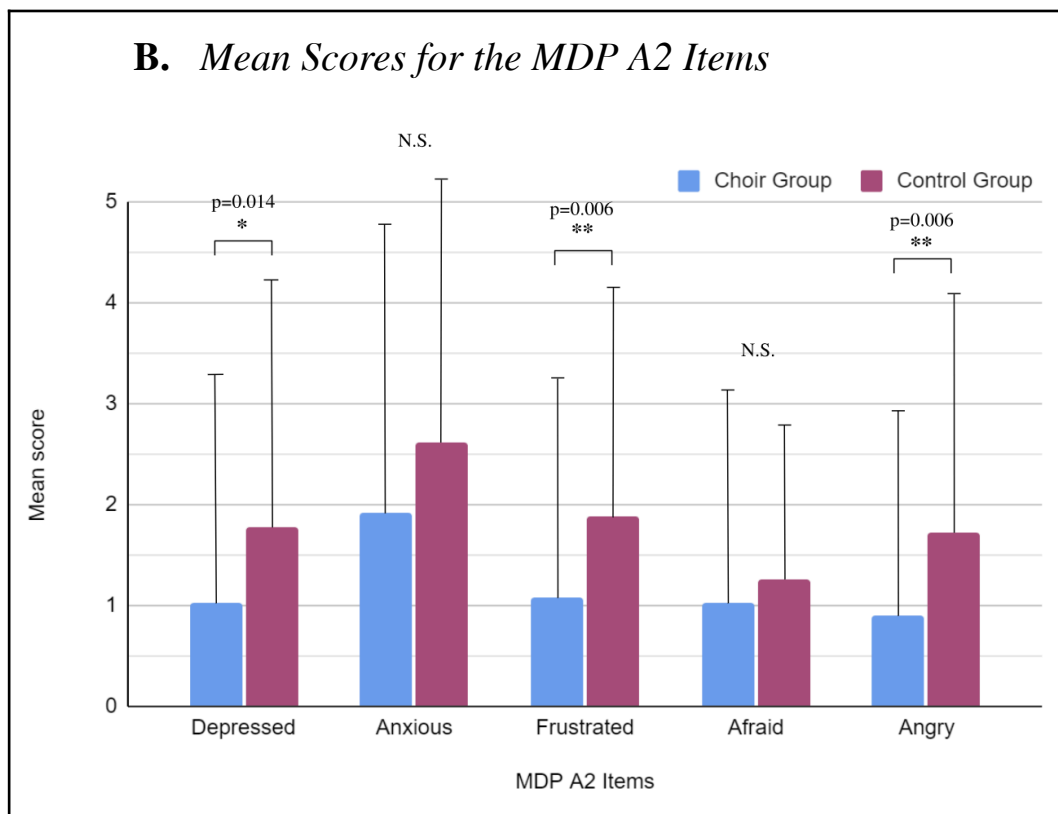
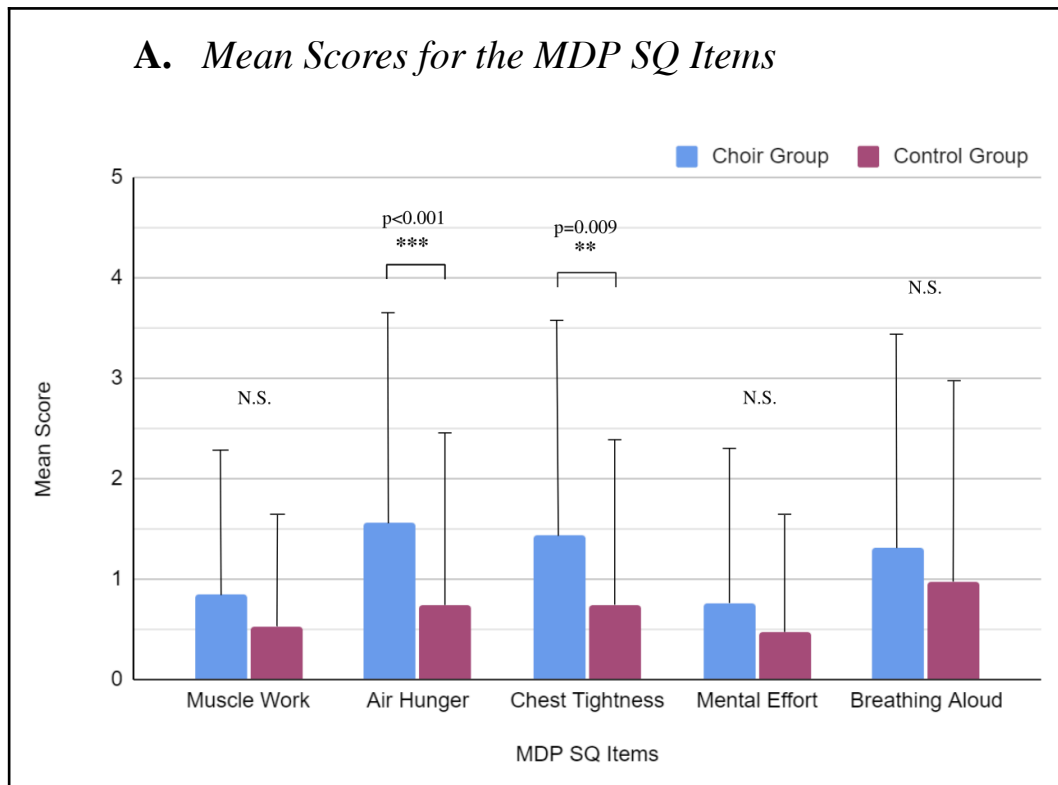
subscales were similar between obese participants and those with a BMI <30 (A1: p=0.261, SQ: p=0.418, A2: p=0.305).

Table 2. *Screening Outcomes for Dysfunctional Breathing Symptoms*

	Choir Group (n=180)	Control Group (n=90)	Comparison
Nijmegen Questionnaire			
Total Score	15.1 (±9.1)	15.9 (±8.1)	p=0.501
Score >23 [n (%)]	28 (15.6%)	17 (18.9%)	p=0.488
Respiratory Symptoms	4.1 (±3.3)	3.4 (±2.9)	p=0.096
Respiratory Symptoms >5 [n (%)]	56 (31.1%)	19 (21.1%)	p=0.084
HADS-A			
Total Score	7.3 (±3.9)	7.5 (±4.1)	p=0.693
Score ≤7 [n (%)]	108 (60%)	47 (52.2%)	
Score [8-10] [n (%)]	35 (19.4%)	21 (23.3%)	p=0.476
Score ≥11 [n (%)]	37 (20.6%)	22 (24.4%)	
MDP			
A1	1.50 (±2.01) ^a	1.26 (±1.73) ^a	p=0.339
SQ	5.96 (±8.26)	3.71 (±6.83) ^a	p=0.019*
A2	6.04 (±9.54)	9.47 (±10.59) ^a	p=0.008**
BPAT	2.7 (±1.6) ^a	N/A	N/A
BHT (seconds)			
t1	26.32 (±12.91) ^a	N/A	N/A
t2	43.64 (±18.98) ^a	N/A	N/A

Data are presented as Mean (±Standard Deviation) ; ^a 1 missing value ; n: number of participants ; HADS-A: Hospital Anxiety and Depression Scale Anxiety subscale ; MDP: Multidimensional Dyspnea Profile ; A1: Affective subscale No. 1, evaluates respiratory discomfort ; A2: Affective subscale No. 2, evaluates the emotional response to dyspnea ; SQ: Sensory Quality subscale, assesses sensory perceptions ; BPAT: Breathing Pattern Assessment Tool ; BHT: Breath-Holding Time ; t1: BHT at first sensations of breathing discomfort ; t2: BHT at spontaneous cessation or involuntary respiratory movements ; N/A: Not Applicable ; p: p-value ; * p<0.05 ; ** p<0.01

Figure 2. Participants' Scores on MDP SQ and A2 Items



Each item scores from 0 to 10 ; MDP: Multidimensional Dyspnea Profile ; SQ: Sensory Quality subscale, assesses sensory perceptions ; A2: Affective subscale No. 2, evaluates the emotional response to dyspnea ; N.S.: Non-Significant ; p: p-value ; * p<0.05 ; ** p<0.01 ; *** p<0.001 ; Error bars represent the Standard Deviation

BPAT

Among the choir participants, 14.4% (n=26) exhibited a positive score on the BPAT (≥ 4), suggesting an impairment in the breathing pattern. No difference was found between the mean scores of males and females ($p=0.284$).

BHT

Within the choir group, females had a lower mean BH t2 score (40.50 seconds ± 15.90) than males (50.21 seconds ± 22.99), with a mean difference of -9.71 seconds (95% CI [-16.36 to -3.06], $p=0.005$). No sex difference was found for BH t1 ($p=0.387$). There was also no difference in mean BH t1 ($p=0.404$) or BH t2 ($p=0.897$) between participants with a positive NQ score and those with a score below the cutoff value.

3.3 Analysis of Variable Relationships

When no intergroup differences were observed, the analyses of relationships between variables were conducted on all participants (n=270). For BPAT and BHT, these analyses were performed only within the choir group (n=180), and for the practice of a group leisure activity, only within the control group (n=90). For MDP, given that statistically significant differences were found, the relationship analyses were performed within each group separately (n=180 for the choir group, n=90 for the control group).

3.3.1 Chi-Square Independence Tests

In our sample, females and smokers were more likely to have a positive screening for SHV symptoms and to experience anxiety compared to males and non-smokers. Indeed, 21.3% of females had a positive NQ score versus 6.9% of males ($p=0.003$), and 48.6% of females had a score ≥ 8 on the HADS-A compared to 28.9% of males ($p=0.004$). Tobacco use was also associated with these outcomes, 39.3% of smokers had a positive SHV screening compared to 14% of non-smokers ($p=0.001$), and 60.7% of smokers had a positive HADS score compared to 40.5% of non-smokers ($p=0.041$).

Participants with respiratory conditions were more likely to have a positive NQ score compared to other participants (P: 40.7% vs. 14.6%, $p=0.028$). Moreover,

individuals with any reported condition (respiratory, cardiac, or psychiatric) had a higher proportion of positive scores on the NQ respiratory symptoms subscale (P: 39.4% vs. 23.4%, $p=0.015$), HADS-A (P: 54.5% vs. 37.8%, $p=0.024$), and BPAT (P: 23.4% vs. 11.4%, $p=0.044$) compared to healthy participants.

Additionally, overweight and obese participants were more prone to have a positive screening for BPD compared to participants with a BMI <25 (P: 25% vs. 8%; $p=0.002$). Thus, among participants with a BPAT score ≥ 4 , 65.4% were overweight or obese. No other relationships were found regarding sociodemographic characteristics and the results of DB symptoms screening tools. Regarding the relationships between the DB symptoms screening tools, participants with a HADS-A score ≥ 8 had a higher proportion of positive scores on the NQ (P: 82.2% vs. 17.8%, $p<0.001$) and abnormal score on its respiratory symptoms subscale (P: 73.3% vs. 26.7%, $p<0.001$) than other participants. A positive BPAT score was not associated with scores from other screening tools.

3.3.2 Correlation Coefficients

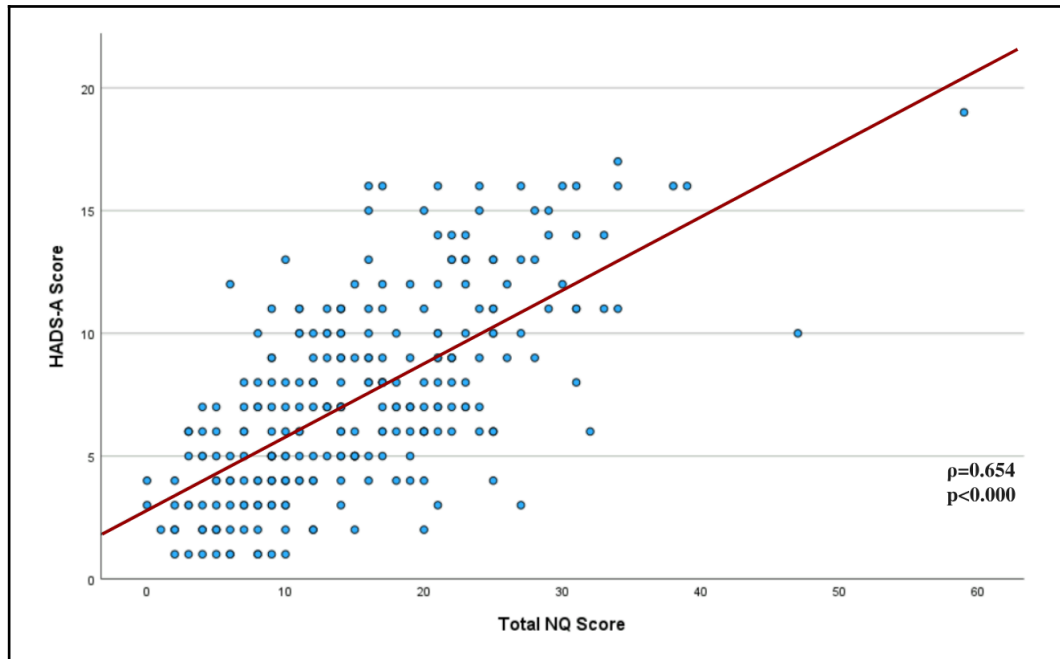
The correlation analysis revealed mostly weak relationships, with coefficients below 0.250. Among coefficients >0.300 , we found a weak correlation between BH t1 and Respiratory Rate ($\rho=-0.301$, $p<0.001$) within the choir group. Among stronger correlations, the NQ total score was strongly related to the NQ respiratory symptoms subscore ($\rho=0.845$, $p<0.001$). HADS-A was strongly correlated with NQ ($\rho=0.654$, $p<0.001$) (Figure 3) and moderately with the NQ respiratory symptoms subscale ($\rho=0.516$, $p<0.001$). In both groups, MDP showed moderate to strong correlations with NQ, the NQ respiratory symptoms subscale, and HADS-A, all with p -values <0.001 (Table 3). The strongest correlations were observed in the control group. The A1 and A2 subscales had their highest correlations with the NQ in the control group ($\rho=0.615$, $\rho=0.545$, respectively) and with the respiratory symptoms subscale in the choir group ($\rho=0.597$, $\rho=0.497$, respectively). The SQ subscale showed its strongest correlations with the NQ respiratory symptoms subscale in both groups (choir group: $\rho=0.597$; control group: $\rho=0.658$). No other moderate or strong correlations were found.

Table 3. Spearman's Rho Correlation Matrix Within Each Group: NQ Total Score, NQ Respiratory Symptoms Subscore, and HADS-A with MDP Subscales Scores

	Total NQ Score	Respiratory Symptoms Subscore of the NQ	HADS-A
Choir Group (n=180)			
MDP A1^a	$\rho=0.547$	$\rho=0.597$	$\rho=0.390$
MDP SQ	$\rho=0.513$	$\rho=0.597$	$\rho=0.421$
MDP A2	$\rho=0.463$	$\rho=0.497$	$\rho=0.421$
Control Group (n=90)			
MDP A1^a	$\rho=0.615^+$	$\rho=0.576$	$\rho=0.539$
MDP SQ^a	$\rho=0.607^+$	$\rho=0.658^+$	$\rho=0.442$
MDP A2^a	$\rho=0.545$	$\rho=0.535$	$\rho=0.475$

All p-values are <0.001. ; ^a 1 missing value ; n: number of participants ; NQ: Nijmegen Questionnaire ; HADS-A: Hospital Anxiety and Depression Scale Anxiety subscale ; MDP: Multidimensional Dyspnea Profile ; A1: Affective subscale No. 1, evaluates respiratory discomfort ; SQ: Sensory Quality subscale, assesses sensory perceptions ; A2: Affective subscale No. 2, evaluates the emotional response to dyspnea ; ρ : Spearman's Rho ; ⁺ $\rho>0.600$: strong correlation

Figure 3. Spearman's Rho Correlation Between NQ and HADS-A Scores for All Participants (n=270)



Scatter plot of the HADS-A score and the total NQ score with the linear prediction line. n: number of participants ; NQ: Nijmegen Questionnaire ; HADS-A: Hospital Anxiety and Depression Scale Anxiety subscale ; p: p-value ; ρ : Spearman's Rho ; $\rho>0.600$ indicates a strong correlation

4. DISCUSSION

4.1. Interpretation of findings

Primary Objective

To our knowledge, this study was the first to measure DB symptoms in an amateur choir singer population and compare them to those of non-singers.

This study included a higher proportion of females than males (67.8% females), which reflects the choir singer population, as women are more likely to participate in choir singing than men. Studer et al. (2011, 2012) reported similar female proportions in their samples of musicians and music students (60% and 61%, respectively). However, this distribution does not represent the general population.

Regarding DB symptoms, there was no difference in the NQ score or in its respiratory symptoms subscore between the two groups. However, there were more smokers in the control group than in the choir group (20% vs. 5.6%), and they were more likely to have a positive NQ score or a HADS-A score ≥ 8 . This difference could be explained by the fact that participating in an activity that increases community group interaction and is highly entitative (i.e., the perception of high group coherence increased by the high level of synchrony in choir singing), such as choir singing, leads to more healthy behaviors (Kang et al., 2018; Stewart & Lonsdale, 2016). Otherwise, singers might pay more attention to their respiratory health for performance purposes (Studer et al., 2011). Nevertheless, this could influence the between-group comparison (Lewis et al., 2018).

Additionally, the proportion of amateur choir singers with a positive NQ score measured in this study is lower than that reported by Widmer et al. (1997) among professional musicians (15.1% vs. 20.1%). This difference persists despite our sample having a higher proportion of females than theirs (their sample includes as many women as men), while females are more likely to have a positive NQ score (Courtney, 2017; Steinmann et al., 2023; Studer et al., 2011). Similarly, the respiratory symptoms subscore in the choir group is lower than that reported by

Studer et al. (2011) in a sample of professional singers and wind players with a similar sex ratio (4.1 ± 3.3 vs. 6.2 ± 4.0). In their study, singers and wind players had a higher score on this subscale than other musicians. Thus, amateur choir singers have less DB symptoms than professional singers and wind players. This difference may be due to Music Performance Anxiety (MPA), which is associated with public performances and is common among professional musicians (Guyon et al., 2020; Studer et al., 2011; Widmer et al., 1997). Indeed, amateur choir singers did not have higher anxiety scores on the HADS-A than non-singers.

The only statistically significant differences observed in the results from DB screening tools pertain to the MDP. Choir singers reported a greater perception of the sensory quality of dyspnea but experienced less negative emotions associated with it compared to non-singers. This difference was not explained by different proportions of obese participants or smokers in the two groups, as the mean scores in the SQ and A2 subscales were similar within these different categories (i.e., $BMI \geq 30$ vs. <30 or smokers vs. non-smokers). Therefore, a higher MDP score related to sensory quality might be due to a greater focus on respiratory sensations by choir singers because of the nature of their hobby (Studer et al., 2011). A lower score on the emotional component of dyspnea could be attributed to the accumulation of positive enjoyable experiences related to their breathing during rehearsals. This might disrupt the vicious cycle of DB, leading to a ‘desensitization’ of breathlessness, as mentioned earlier in the study (Courtney, 2017; Hagman et al., 2011; Herer, 2013; Lewis et al., 2016, 2017; Martinez, 2008; Vidotto et al., 2018). Otherwise, people who choose to join a choir might simply have fewer negative feelings related to their breathing before engaging in this activity. Additionally, although there is no Minimal Clinically Important Difference (MCID) for the MDP regarding the general population suffering from breathlessness or for DB, Ekström et al. (2020) suggest that the MCID for the MDP is similar across the different cardiorespiratory conditions. Therefore, the mean difference between groups regarding the SQ subscale is lower than the MCID determined for various respiratory conditions (mean difference=2.25, MCID=4.63), while for the A2 subscale, this difference exceeds the MCID (mean

difference=-3.43, MCID=2.37). Thus, the only clinically significant difference concerns the A2 score.

In this study, 14% of amateur choir singers had a positive BPAT score, suggesting an alteration in the breathing pattern. However, it was the first to assess breathing patterns among singers using the BPAT, and there are no existing BPAT scores reported for the general population in the literature. Due to feasibility constraints, we only applied the BPAT to the choir group, which limits the interpretation of our findings. Nonetheless, amateur choir singers demonstrated a lower central tendency score compared to patients with DB (2.7 ± 1.6 vs. 6 [3-13]) (Todd et al., 2018). Although the sample in the Todd et al. study included a higher proportion of females, this is unlikely to affect the results, as we found no sex difference in BPAT scores. Therefore, amateur choir singers have lower BPAT scores than patients with DB, with their mean score being below the cutoff of 4. The mean BHT until the first involuntary respiratory movements or after a spontaneous cessation among amateur choir singers in our sample is lower than the value reported by Jack et al. (2003) for healthy participants (mean difference=-19.36 seconds), but higher than that for patients with DB (mean difference=23.44 seconds). However, they did not provide the socio-demographic characteristics of the participants in their study. Therefore, if their sample had a smaller proportion of females, this could account for the difference in scores compared to healthy subjects, as women have shown a lower mean maximal BHT than men.

No relationship was found between the duration of choir singing practice or the frequency of rehearsals attended and the scores on DB symptoms screening tools. However, other studies have reported a dose-response relationship between singing practice and changes in respiratory function (Gould & Okamura, 1973), as well as in various outcomes measured during singing interventions for patients with respiratory conditions (Engen, 2005; Kang et al., 2018; Lewis et al., 2018; McNaughton et al., 2016).

Finally, this study suggests that choir singing may not increase DB symptoms and might have a protective or beneficial effect on the emotional perception of

dyspnea, unlike professional singing. There seems to be no contraindication to practicing singing in the context of DB, and no studies involving singing interventions have reported adverse events (Daugherty, 2013; Lewis et al., 2016; Ly et al., 2022).

Although more reliable evidence is needed regarding the effects of choir singing on DB (Kaasgaard et al., 2022; Kang et al., 2018; Lewis et al., 2016, 2018; Ly et al., 2022; Sliwka et al., 2012), a singing-based approach could be beneficial for managing DB symptoms and impacts (Gick & Nicol, 2016; Philip et al., 2019; Reagon et al., 2016; Stewart & Lonsdale, 2016). Singing interventions have shown positive effects on various respiratory conditions with high DB prevalence and fits well within a biopsychosocial framework (Fancourt & Finn, 2019; Gick & Nicol, 2016; Philip et al., 2019). Patient-centered approaches that consider the patient's expectations and interests could enhance treatment outcomes and adherence. Therefore, in this patient-centered paradigm group singing could serve as a complementary intervention for patients who have positive beliefs about choir singing or who enjoy this activity (Canga et al., 2015; Gick & Daugherty, 2015; Loewy et al., 2021; Lord et al., 2010, 2012; McNamara et al., 2019; McNaughton et al., 2016; Philip et al., 2019; Philip et al., 2022).

However, participants in singing interventions for respiratory conditions often value the social connections with others who suffer from the same condition (Engen, 2005; Goldenberg, 2018; Reagon et al., 2016), while community choirs primarily include healthy individuals. Additionally, although choir singing has shown beneficial effects on asthma patients outside the medical care setting (Daugherty, 2013; Gick & Daugherty, 2015), it cannot replace medical interventions for DB, including the treatment of psychiatric comorbidities (Barker et al., 2018; Courtney, 2017; Frésard et al., 2022; Lewis et al., 2018). Furthermore, therapeutic education is necessary to enhance health literacy which remains essential for the improvement in self-efficacy that singing approaches could offer (Kopitović & Mirić, 2023; Ly et al., 2022; Reeves et al., 2014). Consequently, hybrid rehabilitation protocols that incorporate singing, similar to the approach used by Lewis et al. (2022) with Singing for Lung Health, could be an effective way to integrate it into a more traditional care. Alternatively, group singing could be offered as a recreational activity alongside DB treatment.

Secondary Objective

The proportion of females and males with a positive score on the NQ found in this study is higher than that reported by Thomas et al. (2005) among the general population. Indeed, we found 21.3% of females with a positive NQ score compared to 14% in their sample, and 6.9% of males compared to 2%. This difference, which is not influenced by the different sex proportions of the samples, suggests an increase in the number of individuals with a positive screening for DB symptoms since the COVID-19 pandemic. Moreover, the proportion of participants with a positive score on the NQ in our sample is lower than that reported by Steinmann et al. (2023) during the pandemic (16.7% vs 24%), while this study included almost 20% more females. This difference could be explained by a decrease in fear and awareness of respiratory symptoms and sensations since the end of the pandemic (Steinmann et al., 2023). Thus, while the prevalence of DB symptoms has decreased since the end of the COVID-19 pandemic, it remains higher than pre-pandemic rates.

This study showed sex differences in DB screening tools consistent with the existing literature. Females had more DB symptoms and experienced more anxiety compared to males (Courtney, 2017; Koniukhovskaia et al., 2021; Sedeh et al., 2020; Sliwka et al., 2012; Studer et al., 2011). However, for the MDP, males scored higher than females across all three subscales, with mean differences exceeding the MCIDs (Ekström et al., 2020). Specifically, males scored on average 1.59 points higher on the A1 scale (MCID=0.82), 6.68 points higher on the SQ scale (MCID=4.63), and 4.39 points higher on the A2 scale (MCID=2.37). Thus, while females reported more DB symptoms, their perceived dyspnea was lower compared to males. This contrasts with the positive association between a NQ positive score and dyspnea described in the literature (Boulding et al., 2016; Courtney et al., 2011; Todd et al., 2018; Watson et al., 2021).

Additionally, in the sample of amateur choir singers, females had a lower maximal BHT compared to males. This difference may partly be attributed to the generally smaller body size of females, which results in a lower vital capacity (Binazzi et al., 2006). Moreover, Gross (1953) suggested that a lower BHT is primarily

associated with the affective perception of dyspnea. Nevertheless, males had high BHT and a heightened negative affective perception of dyspnea.

As expected, a high proportion of participants with respiratory conditions tested positive for DB symptoms on the NQ (Barker & Everard, 2015; Boulding et al., 2016; Bouteleux et al., 2021; Kopitović & Mirić, 2023; Law et al., 2018; Lewis et al., 2022; Sedeh et al., 2020; Thomas et al., 2001). Participants with any reported conditions also had higher rates of positive scores on the NQ respiratory symptoms subscale, HADS-A, and BPAT. Thus, secondary DB is more common than primary DB but often underdiagnosed (Boulding et al., 2016; Chenivresse et al., 2014; Daugherty, 2013; Depiazzi & Everard, 2016; Law et al., 2018; Loewy et al., 2021). It should be carefully considered in patients with psychiatric or cardiorespiratory conditions who experience *disproportionate breathlessness* (i.e., significantly greater than expected despite optimal treatment of the underlying condition) (Barker & Everard, 2015; Boulding et al., 2016; Watson et al., 2021). In this study, BPD was associated with obesity and being overweight. Indeed, 65.4% of participants with a positive BPAT score were overweight or obese. Although Todd et al. (2018) did not identify this relationship during their validation process, other studies have reported associations between DB and BMI (Cesanelli et al., 2024; Guyon et al., 2020; Kopitović & Mirić, 2023; Sedeh et al., 2020). This could be explained by the link between excess weight and deconditioning, which increases breathlessness (Sedeh et al., 2020) or by mechanical disadvantages for respiratory muscles due to changes in thoraco-pulmonary and abdominal compliance resulting from adipose tissue accumulation (Cesanelli et al., 2024; Kopitović & Mirić, 2023). However, participants in these BMI categories did not have a higher rate of positive NQ scores, and obese participants did not report a greater perception of dyspnea compared to others.

Previous studies have identified relationships between the BPAT or the MARM (Manual Assessment of Respiratory Motion, another BPD assessment tool) and various DB symptoms screening tools, particularly Dyspnea 12 and the NQ (Courtney, van Dixhoorn, et al., 2011; Hylton et al., 2022; Todd et al., 2018). However, this study did not find any association between the BPAT and other DB

symptoms assessment tools. Similarly, no linear correlation was found between the BHT and other DB symptoms assessment tools as reported in other studies (Bradley & Esformes, 2014; Courtney, Greenwood, et al., 2011; Kiesel et al., 2017; Stanton et al., 2008). Moreover, in the sample of amateur choir singers, BHT were similar among participants with a positive NQ score and those with scores below the cutoff value.

This study identified some moderate to strong linear correlations. Indeed, the NQ demonstrated a strong correlation with its respiratory symptoms subscale and the HADS-A. The respiratory symptoms subscale displayed a weaker correlation with the HADS-A. The MDP also exhibited strong correlations with the NQ and its respiratory symptoms subscale, and a moderate correlation with the HADS-A. This confirms that perceived DB symptoms and dyspnea are correlated with experienced anxiety, as mentioned in the literature (Courtney, 2017; Gick & Nicol, 2016; Guyon et al., 2020; Herer, 2013; Jack et al., 2003; Stephen et al., 2022; Widmer et al., 1997; Yohannes et al., 2017).

Finally, this study reinforces the importance of being attentive to potential signs of DB in populations at higher risk, including women, individuals who are overweight or obese, and those with anxiety, psychiatric conditions, or cardiorespiratory diseases. DB should always be considered in the presence of *disproportionate breathlessness* that can not be explained by the underlying condition among patients with cardiorespiratory diseases (Kopitović & Mirić, 2023; Law et al., 2018; Watson et al., 2021).

Furthermore, while the BPAT and BHT did not show relationships with other DB symptoms screening tools, the absence of an association with the NQ does not mean that they are ineffective for DB screening. Indeed, the NQ is merely a tool for measuring DB symptoms, not a diagnosis tool for this condition. Therefore, this highlights the importance of using multiple tools in DB screening to assess all aspects of this condition within a biopsychosocial approach (Barker et al., 2020; Courtney, Greenwood, et al., 2011; Kopitović & Mirić, 2023; Watson et al., 2021).

4.2. Limitations

One of the strengths of this study is the sample size, which exceeds that of previous studies evaluating DB symptoms among singers or assessing the effects of singing interventions. However, there are several limitations that may impair the generalization of our findings.

Firstly, the gender distribution in our sample, while representative of the amateur choir singer population, limits the generalization of the results to the general population. This affects the external validity of the study. Additionally, the higher proportion of smokers in the control group could be a confounding variable. Smokers also exhibited higher levels of anxiety, and although anxiety and DB are known to aggravate each other, the causal relationship between them remains uncertain (Boulding et al., 2016; Gick & Nicol, 2016; Widmer et al., 1997; Yohannes et al., 2017). Therefore, individuals with greater anxiety and DB symptoms might be more inclined to smoke as a coping mechanism. Conversely, smoking could worsen DB symptoms, leading to an increased anxiety.

This study involved participants from various choirs, some of which are more demanding than others, partly due to the higher number of public performances, which are known to increase anxiety (i.e., MPA) and DB symptoms (Kang et al., 2018; R. Studer et al., 2011; R. K. Studer et al., 2012; Widmer et al., 1997). These choirs also experience greater financial pressure, as performance incomes are essential for their survival, which may further heighten anxiety and DB symptoms. Additionally, the choirs included in the study perform different musical styles (Appendix G), which might have diverse effects on respiratory functions (Irons et al., 2016, p. 201; Lewis et al., 2018; Salomoni et al., 2016).

Moreover, the screening tools for DB symptoms have several limitations. The BPAT measures the breathing pattern at a specific moment (Todd et al., 2018), while DB symptoms are often intermittent (Barker et al., 2020) and may not be identified by a single assessment. Additionally, regarding the BHT, multiple protocols are described in the literature, with no consensus on which one is the best for screening DB (Courtney & Cohen, 2008; Jack et al., 2003; Kiesel et al., 2017; Kopitović & Mirić, 2023). Thus, the protocol used in this study might not be the most suitable for this purpose. Additionally, this study did not cover all

aspects of DB, such as the biochemical dimension or the QoL, which are important components of this condition (Barker et al., 2020; Chenivesse et al., 2014; Kopitović & Mirić, 2023).

Finally, the main limitation affecting the external validity of this study lies in its design. As an observational study, it cannot establish causality (Pai et al., 2008). Thus, despite the between-group comparison results, we cannot draw conclusions about the effect of choir singing on DB symptoms. Although we measured a wide range of variables to minimize confounding factors, this study only presents the difference in DB symptoms between the two populations.

4.3 Prospects

To assess the potential effects and benefits of amateur choir singing on DB management, more reliable evidence is needed through high-quality studies such as RCTs (Gick & Nicol, 2016; Kang et al., 2018; Lewis et al., 2016, 2018; Sliwka et al., 2012). Since dyspnea and reduced QoL are key issues in DB (Chenivesse et al., 2014; Kopitović & Mirić, 2023), it seems important to include these aspects into the evaluation of singing interventions. Additionally, it would be valuable to specifically measure the impact of choir singing on DB independently of any medical treatment, as done by Gick & Daugherty (2015) with asthma patients. Their study included three intervention groups: (i) choir singing alone, (ii) choir singing combined with usual rehabilitation, and (iii) usual rehabilitation alone. They found similar results across all three groups demonstrating the inherent benefits of choir singing for this condition. It would also be relevant to conduct more high-quality studies comparing the effects of group singing to those of other group leisure activities (Stewart & Lonsdale, 2016), as done for other conditions (Lord et al., 2010, 2012; Martinez, 2008; Stewart & Lonsdale, 2016).

However, obtaining high-quality evidence from singing interventions is challenging, as blinding does not seem to be possible (Gick & Nicol, 2016; Lewis et al., 2016). Moreover, the effectiveness of this approach partly relies on participants' interest and positive beliefs (Gick & Daugherty, 2015; Gick & Nicol, 2016; Lord et al., 2012), therefore randomization may limit these effects by not

targeting patients who could benefit the most from the intervention. Additionally, to minimize bias, it seems necessary to clearly describe protocols used in singing-based interventions, which has not always been done in previous studies. Greater consistency in intervention protocols is also needed to compare the results of different studies, draw conclusions, and establish recommendations (Kang et al., 2018; Lewis et al., 2016; K. Philip et al., 2019; Sliwka et al., 2012).

5. CONCLUSION

Amateur choir singers expressed similar DB symptoms than non-singers and appear to have less symptoms than professional or student singers. They experienced a greater perception of the sensory quality of dyspnea than non-singers, which was not clinically significant (below the MCID). Contrariwise, they had a clinically significantly lower negative emotional perception. There was no relationship between the duration of choir practice or the frequency of rehearsals attended and DB assessment tools. Thus, although it cannot draw conclusions about the effect of amateur choir singing on DB symptoms, this study supports the need for further research into group singing interventions for DB.

Consistent with the literature, our findings suggest that DB should be given more consideration in females, overweight and obese individuals, as well as patients with cardiorespiratory or psychiatric conditions. Therefore, DB screening is greatly recommended for these populations when suggestive signs are observed. Interestingly, although males had fewer DB symptoms than females, they reported a higher sensory quality and a more negative affective perception of dyspnea. Some moderate to strong correlations were found between anxiety, DB symptoms, and dyspnea. However, BPAT and BHT did not show any relationship with the other DB symptoms screening tools used. Therefore, DB screening requires a multidimensional approach, using multiple tools to assess the different components of the condition.

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7. APPENDICES

Appendix A. Ethic Committee Approval



Université Catholique de Louvain
Faculté de médecine



Comité d'Éthique Hospitalo-Facultaire

Bruxelles, ce 14 mars 2024

A l'investigateur responsable:
Dr. Grégory REYCHLER
Pneumologie
Cliniques Universitaires Saint-Luc

AVIS FAVORABLE DEFINITIF

Concerné : 2023/12DEC/508 - N° Enregistrement Belge : B4032023000141

N° Protocole : SHVCHOR

Acronyme : SHVCHOR

Intitulé : Comparaison de la prévalence d'une dysfonction respiratoire chez les choristes et les non-choristes

Cher Collègue,

Le Comité d'Éthique Hospitalo-Facultaire Saint-Luc - UCL a pris connaissance de l'étude susmentionnée. Nous avons examiné l'ensemble des documents concernant cette étude, y compris les documents modifiés suite aux remarques :

- Document 1, reçu le 12/12/2023
- Protocole, Version 3 – Clean et tracked changes, reçus le 15/02/2024
- Résumé en FR, version 2 du 15/10/23
- Document d'Information et de Consentement Participants, Version 3 – Clean et tracked changes, reçus le 15/02/2024
- Questionnaires : (Questionnaire de Nijmegen, Breathing Pattern Assessment Tool, Hospital Anxiety and Depression scale, Questionnaire MDP, Questionnaire d'informations générales et socio-démographiques), reçus le 12/12/2023
- Certificat d'Assurance 2023 Amlin + 2nd Rang
- CVs datés et signés du PI et co-PI, reçus le 12/12/2023
- Questionnaire 1 RGPD, reçu le 12/12/2023
- Déclaration financière, reçu le 12/12/2023
- Aval MVH, reçu le 12/12/2023
- Document de réponse aux remarques du CEHF, reçu le 15/02/2024

En tant que comité d'éthique principal désigné par le promoteur (unique en Belgique), selon les directives de la loi du 07 mai 2004, nous donnons un avis favorable définitif à ce projet.

Nous rappelons à l'investigateur qu'il est personnellement responsable de cette étude et au promoteur qu'il est responsable de la conformité linguistique des formulaires d'information et de consentement.

Aucun participant ne peut être admis dans une expérimentation ou un essai clinique avant que le comité d'éthique (IRB/IEC) n'ait donné un avis écrit favorable au projet.

Aucune modification ni changement au protocole ne peut être mis en route sans l'approbation préalable écrite du comité d'éthique à l'amendement approprié excepté les situations prévues dans les bonnes pratiques cliniques (BPC/GCP).

Comité d'Éthique Hospitalo-Facultaire

Le comité d'éthique principal déclare qu'il procède selon les directives ICH/GCP, les lois et règlements applicables, et ses propres procédures écrites.

Le comité d'éthique principal déclare qu'aucun de ses membres ayant une affiliation avec l'étude ou le sponsor n'a voté pour cette étude.

Une liste des membres actuels est jointe en annexe.

Le comité d'éthique principal sera continuellement informé de tous les SUSAR et déviations liés à ce protocole et qui se sont produits en Belgique.

Le comité d'éthique sera également informé du statut de l'étude sur base continue (comme requis par les directives ICG-GCP 4.10.1).



Nous vous prions d'agréer, cher Collègue, l'expression de nos sentiments les meilleurs.



Mme I. de HEMPTINNE
Membre CEHF



Prof. J.-M. MADOTEAUX
Président

 CEHF-FORM-006-17.0	Composition du Comité d'éthique hospitalo-facultaire nominatif	 Commission d'éthique hospitalo-facultaire
		Date d'application : 13/11/2023

Comité d'éthique hospitalo-facultaire (CEHF)

COMPOSITION (cfr CEHF-DSQ-005_Description fonctionnement CEHF)	
<ul style="list-style-type: none"> ▪ Président ▪ Vice-présidents ▪ Secrétaire ▪ Docteurs en Médecine attachés aux Cliniques Universitaires Saint-Luc ou à la Faculté de Médecine de l'UCL ▪ Médecins Omnipraticiens ou Extérieurs aux Cliniques Universitaires Saint-Luc ▪ Ethicien ▪ Juriste ▪ Infirmières (Cliniques universitaires Saint-Luc) et Assistante Sociale ▪ Psychologue ▪ Pharmaciens Hospitalier des Cliniques Universitaires Saint-Luc ▪ Méthodologiste ▪ Collaborateurs Scientifiques, PhD ▪ Représentants Patients ▪ Représentants Volontaires Sains 	<ul style="list-style-type: none"> ▪ Jean-Marie MALOTEAUX, Docteur en médecine ▪ Véronique DUVEILLER, Pharmacien ▪ Emmanuelle VAN HELLEPUTTE, Juriste et représentante des patients ▪ Yves HUMBLET, Docteur en médecine ▪ Isabelle SCHEERS, Docteur en médecine ▪ Martine BERLIERE ▪ Yves HORMANS ▪ Luc ROEGIER¹ ▪ Bénédicte BRICHARD ▪ Christiane VERMYLEN ▪ Dominique LAMY ▪ Patrick EVRARD (Cliniques Mont-Godinne)¹ ▪ Eric GAZIAUX ▪ Alain LOUTE ▪ Geneviève SCHAMPS ▪ Cécile COUPEZ ▪ Oknam MICHOTTE¹ ▪ Nicolas VERMEULEN¹ ▪ Pascale de PIERPONT¹ ▪ Séverine HALLEUX¹ ▪ Niko SPEYBROECK ▪ Isabelle de HEMPTINNE¹ ▪ Anne GABRIEL¹ ▪ Luc DUVEILLER¹ et/ou Aurélie CARLIER¹ ▪ Olivier BLEUS et/ou Stéphanie CHAPUT¹

¹: invité

Appendix B. *Nijmegen Questionnaire French Version*

Questionnaire de Nijmegen :

1. J'ai des tensions nerveuses :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
2. J'ai une incapacité à respirer profondément :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
3. Ma respiration est accélérée ou ralentie :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
4. Ma respiration est courte :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
5. J'ai des palpitations :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
6. Mes extrémités sont froides :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
7. J'ai des vertiges :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
8. Je me sens anxieux(-euse) :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
9. Je sens ma poitrine serrée :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
10. J'ai des douleurs thoraciques :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
11. Il m'arrive de voir flou :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
12. Je ressens des fourmillements dans les doigts :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
13. Mes bras et mes doigts sont lourds, ankylosés, difficiles à bouger :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
14. Je me sens confus :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
15. Mon ventre est ballonné :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent
16. Je ressens des fourmillements autour de ma bouche :
 - Jamais
 - Rarement
 - Parfois
 - Souvent
 - Très souvent

Appendix C. Hospital Anxiety and Depression Scale - Anxiety Subscale French Version

1. Je me sens tendu(e) ou énervé(e)
 - La plupart du temps
 - Souvent
 - De temps en temps
 - Jamais

2. J'ai une sensation de peur comme si quelque chose d'horrible allait m'arriver
 - Oui, très nettement
 - Oui, mais ce n'est pas trop grave
 - Un peu, mais cela ne m'inquiète pas
 - Pas du tout

3. Je me fais du souci
 - Très souvent
 - Assez souvent
 - Occasionnellement
 - Très occasionnellement

4. Je peux rester tranquillement assis(e) à ne rien faire et me sentir décontracté(e)
 - Oui, quoi qu'il arrive
 - Oui, en général
 - Rarement
 - Jamais

5. J'éprouve des sensations de peur et j'ai l'estomac noué
 - Jamais
 - Parfois
 - Assez souvent
 - Très souvent

6. J'ai la bougeotte et n'arrive pas à tenir en place
 - Oui, c'est tout à fait le cas
 - Un peu
 - Pas tellement
 - Pas du tout

7. J'éprouve des sensations soudaines de panique
 - Vraiment très souvent
 - Assez souvent
 - Pas très souvent
 - Jamais

Appendix D. Multidimensional Dyspnea Profile French Version

PROFIL MULTIDIMENSIONNEL DE LA DYSPNÉE

Texte de présentation pour la première utilisation :

Ce questionnaire a pour objet de nous aider à comprendre comment vous percevez et ressentez votre respiration. Il n'y a pas de bonne ou de mauvaise réponse. Nous souhaitons savoir ce que vous avez à nous dire au sujet de votre respiration.

Nous allons tout d'abord vous demander à quel point vous trouvez votre respiration désagréable. Nous parlerons ensuite de l'intensité (la force) de vos sensations respiratoires. Pour vous aider à différencier le caractère désagréable et l'intensité, imaginez que vous écoutez de la musique, par exemple à la radio. Quand le son augmente, cela peut être plus ou moins désagréable. L'intensité de la sensation correspond au volume sonore. Quant au caractère désagréable, il peut apparaître quand le son augmente ou exister même si le son est faible. Par exemple, une musique que vous détestez sera désagréable même si le volume est faible et deviendra de plus en plus désagréable si le volume augmente. Au contraire, une musique que vous aimez restera agréable même si elle est forte.

Échelle AI (affect)

Utilisez cette échelle pour évaluer le **caractère désagréable ou l'inconfort** de vos sensations respiratoires, le degré de **gêne** que vous ressentez [avez ressenti] en respirant.

Veuillez prendre en considération la période/l'événement suivant(e) : _____

← ← 0 1 2 3 4 5 6 7 8 9 10
 AGRÉABLE NI AGRÉABLE NI GÉNANT INSUPPORTABLE

Choix QS (qualificateurs sensoriels)

Dans le tableau ci-dessous, chaque ligne regroupe des propositions ayant un sens similaire.

Étape 1 : Cochez chaque ligne s'appliquant à vos sensations respiratoires pendant _____ (indiquez la période concernée).

Étape 2 : Choisissez ensuite *une seule* ligne, celle qui s'applique le mieux à vos sensations respiratoires.

Sélectionnez les lignes contenant au moins <i>UNE</i> proposition qui s'applique.	Étape 1		Étape 2
	NE S'APPLIQUE PAS	S'APPLIQUE	S'APPLIQUE LE MIEUX
Je dois fournir un travail <i>ou</i> un effort musculaire pour respirer.			
Je manque d'air <i>ou</i> j'étouffe <i>ou</i> je sens que j'ai besoin d'air.			
J'ai la sensation que ma poitrine et mes poumons sont serrés <i>ou</i> comprimés.			
Je dois me concentrer <i>ou</i> faire un effort mental pour respirer.			
Je respire fort.			

Évaluez toutes les lignes contenant au moins <i>UNE</i> proposition qui s'applique.	JE N'AI PAS ÉPROUVÉ CETTE SENSATION										LA PLUS FORTE INTENSITÉ IMAGINABLE
	0	1	2	3	4	5	6	7	8	9	10
Je dois fournir un travail <i>ou</i> un effort musculaire pour respirer.											
Je manque d'air <i>ou</i> j'étouffe <i>ou</i> je sens que j'ai besoin d'air.											
J'ai la sensation que ma poitrine et mes poumons sont serrés <i>ou</i> comprimés.											
Je dois me concentrer <i>ou</i> faire un effort mental pour respirer.											
Je respire fort.											
Autre*											

*Si nécessaire, vous pouvez ajouter des descriptions supplémentaires de vos sensations respiratoires.

	JE N'AI PAS ÉPROUVÉ CE SENTIMENT										J'AI ÉPROUVÉ CE SENTIMENT DE LA PIRE FAÇON IMAGINABLE
	0	1	2	3	4	5	6	7	8	9	10
Déprimé(e)											
Anxieux(se)											
Frustré(e)											
En colère											
Effrayé(e)											
Autre ?											

Appendix E. Breathing Pattern Assessment Tool Evaluation Grid

Abdominal or upper chest movement: Where is movement occurring in tidal volume breathing at rest?	Abdominal (Diaphragm level and below)	Combination (Movement in both upper chest and abdomen)	Apical (Upper chest rises and falls with each breath)
Inspiratory flow Do they have increased inspiratory flow? This would be indicated by an <u>audible</u> breath <u>IN</u> through either nose or mouth and includes any type of wheeze.	Silent	Audible	Loud
Expiratory flow Do they have increased expiratory flow? This would be indicated by an <u>audible</u> breath <u>OUT</u> through either nose or mouth and includes any type of wheeze.	Silent	Audible	Loud
Channel of inspiration and expiration Are they breathing through their; nose, mouth or a combination of both during the minute assessed?	Nose (with their mouth closed throughout the minute assessed)	Nose and mouth (During the minute some breaths are through their nose and some through their mouth)	Mouth (Breathing with mouth open throughout)
Air hunger During the minute assessed is the patient showing signs of air hunger. This includes yawning, sighing or taking a deeper breath than their tidal breaths?	None	Once per minute	Twice or more times per minute
Respiratory Rate What is their respiratory rate in the minute assessed? TOTAL RR _____	12 or less	13-25	25+
Rhythm Are their breaths evenly spaced throughout the minute? Do they appear regular and rhythmical?	Rhythmical		Erratic
Scoring	0	1	2
Score for each column			
		TOTAL SCORE	

Appendix F. Informational Questionnaire designed by the authors

Questionnaire d'informations générales et socio-démographiques :

1. Quel âge avez-vous ?
2. Vous êtes : - Un homme - Une femme
3. Quelle est votre taille ?
4. Quel est votre poids ?
5. Quelle est votre catégorie professionnelle ?
 - 1 Dirigeants, cadres supérieurs, cadres de direction
 - 2 Professions intellectuelles et scientifiques (ingénieurs, médecins, professeurs, avocats, etc.)
 - 3 Professions intermédiaires (techniciens, infirmiers, comptables, inspecteurs de police, etc.)
 - 4 Employés de type administratif (secrétaires, standardiste, guichetiers, etc.)
 - 5 Personnel des services et de la vente (cuisiniers, serveurs, coiffeurs, pompiers, guides, vendeurs, etc.) Agriculteurs, pêcheurs, etc.
 - 6 Artisans et ouvriers (maçons, charpentiers, couvreurs, plâtriers, potiers, orfèvres, bouchers, boulangers, ébénistes, couturiers, etc.)
 - 7 Conducteurs de machine et de robots industriels, grutiers, chauffeurs de taxi, pilotes de locomotive, etc. Ouvriers et employés non qualifiés (manutentionnaires, éboueurs, livreurs, aides de ménage, vendeurs ambulants, etc.)
6. Quel est votre niveau de formation ?
 - 1 Supérieur de type long, niveau universitaire
 - 2 Supérieur de type court et bachelier
 - 3 Secondaire supérieur
 - 5 Secondaire inférieur
 - 6 Primaire ou sans diplôme
7. Fumez-vous des cigarettes, même occasionnellement ?
8. Avez-vous une maladie respiratoire ?
 - Asthme
 - Bronchopneumopathie chronique obstructive (BPCO)
 - Mucoviscidose
 - Apnée du sommeil
 - Covid long
 - Fibrose pulmonaire
 - Cancer pulmonaire
 - autre :

Questions supplémentaires spécifiques à chaque groupe :

- Pour le groupe chorale :

1. Depuis combien de temps pratiquez-vous la chorale ? (mois/années)

2. À combien de répétitions participez-vous par mois ?

- Pour le groupe contrôle :

Pratiquez vous régulièrement (au moins une fois par semaine) une activité en groupe ?

- Je ne pratique aucune activité en groupe au moins une fois par semaine.
- Je pratique un sport collectif / en groupe au moins une fois par semaine.
- Je suis des cours de danse en groupe au moins une fois par semaine.
- Je suis des cours de musique en groupe au moins une fois par semaine.
- Je pratique une activité créative en groupe, comme de la céramique, des arts plastiques (...), au moins une fois par semaine.
- Je fais une autre activité en groupe au moins une fois par semaine comme du jardinage, de la cuisine, de la couture ...

Appendix G. Characteristics of Choirs Included in the Study

Choirs	Regions of Belgium	Music style	Number of participants
Dreaming Voices	the Namur Region	Contemporary pop	n=26
Harmonic Voices	the Namur Region	Classical	n=12
Sacré-Choeur de Namur	the Namur Region	Global repertoire (including classical)	n=14
La Vaubane	the Namur Region	Contemporary pop	n=42
Voix-ci Voix-là	the Namur Region	Contemporary pop	n=37
La Chanterelle	Walloon Brabant	Contemporary pop	n=11
La Ribambelle	Walloon Brabant	Classical	n=8
Chorale Universitaire de Louvain (for students)	Walloon Brabant	Classical	n=21
Chorale Universitaire de Louvain (for employees)	the Brussels Region	Global repertoire (including classical)	n=15
Total participantsⁱ			N=186

ⁱ The total number of participants in the choir group before the matching group procedure is 186. All choirs, except La Ribambelle, started their sessions with: a general physical warm-up, a phonation muscle warm-up, and vocal exercises. In all choirs, members had the option to sit or stand. Generally, while singing, they mostly stood and sat down when it was the turn for other voices to sing. n: number of participants

Background: Although singing has shown several benefits in the treatment of various respiratory conditions, its effects on Dysfunctional Breathing (DB) remain uncertain. Thus the aim of this study is to compare the prevalence of DB symptoms among amateur choir singers and non-singers, as professional singers reported high DB symptoms rates.

Method: We conducted a cross-sectional comparative study using the Nijmegen Questionnaire (NQ), Hospital Anxiety and Depression Scale - Anxiety Subscale (HADS-A), and the Multidimensional Dyspnea Profile. We also measured the Breath-Holding Time (BHT) and used the Breathing Pattern Assessment Tool (BPAT) in the choir group to compare them with reference values.

Results: The analysis included 270 participants (180 choir singers, 90 non-singers). DB symptoms measured by the NQ and HADS-A scores were similar between the groups ($p=0.501$, $p=0.693$, respectively). However, while choir singers reported a higher sensory quality perception of dyspnea (mean \pm SD: 5.96 ± 8.26 vs. 3.71 ± 6.83 , $p=0.019$), they had a lower negative emotional perception (6.04 ± 9.54 vs. 9.47 ± 10.59 , $p=0.008$) than non-singers. In the choir group, the mean maximal BHT was 43.64 seconds (± 18.98) and mean BPAT score was 2.7 (± 1.6).

Conclusion: Amateur choir singers reported similar DB symptoms than non-singers and fewer than professional singers. They reported a lower negative emotional perception ($>MCID$) but a higher, yet not clinically significant, sensory quality perception of dyspnea.