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Validity and Reliability of the Multidimensional Dyspnoea Profile in Older Adults

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ABSTRACT

Breathlessness is a common and distressing symptom in older adults and an independent predictor of adverse outcomes. Yet, its multidimensional assessment has not been validated in older adults. We apply and validate the Multidimensional Dyspnoea Profile (MDP) in a sample of adults 75 years and older in Belgium.

Breathlessness was rated with the MDP, modified Borg dyspnoea scale, numerical rating scale for intensity and unpleasantness both before and after exertion (the short battery of physical performance tests (SPPB)), as well as with the Medical Research Council dyspnoea scale. The Hospital Anxiety and Depression Scale (HADS) assessed the affective status. Factor structure was analysed with exploratory principal components analysis, internal consistency with Cronbach's alpha and concurrent validity with Spearman's correlation coefficients with other breathlessness scales, HADS and SPPB scores.

In 96 participants (mean age: 85 years; 34% men) who rated breathlessness at both assessment points, exploratory principal components analysis identified two components: immediate perception (IP) and emotional reaction (ER) explaining most of MDP item variance (65.37% before and 71.32% after exertion). Internal consistency was moderate to high for MDP-IP (Cronbach's alpha=0.86 before and 0.89 after exertion) and MDP-ER (Cronbach's alpha= 0.89 before and 0.91 after exertion). The correlation patterns of MDP-IP and MDP-ER with other tests confirmed concurrent validity.

The domain structure, reliability and concurrent validity of MDP for breathlessness before and after exertion were confirmed in a sample of adults 75 years and older, supporting its use and further research for the multidimensional profiling of breathlessness in older adults.

INTRODUCTION

Breathlessness is a common and distressing symptom in older adults with around 30% of them reporting breathlessness during activities of daily living [1, 2]. Breathlessness is not only a symptom of high burden chronic diseases such as cardio-respiratory ones, but also a potential geriatric syndrome and independent marker of higher risk for adverse outcomes in older adults [3-7]. This has led to a call for its systematic and routine assessment [8, 9].

Yet breathlessness is a complex and multidimensional symptom including the sensory-perceptual experience (what breathing feels like), the affective distress (how distressing breathing feels) and the impact (how breathlessness affects functional ability or quality of life) [10]. Despite this, so far breathlessness has been assessed mainly with unidimensional tools [1, 10]. Recently multidimensional tools have been developed and validated such as the Multidimensional Dyspnoea Profile (MDP) [11, 12]. MDP consists of 11 items that cover three domains: (1) unpleasantness/discomfort of the breathing sensation rated in a numerical scale from 0-10; (2) five descriptors of the breathing sensation presented as a choice and the chosen descriptor is rated for its intensity on a numerical scale from 0-10; (3) emotional responses to the breathing sensation (five) to be rated on their intensity in a numerical scale from 0-10 [12]. The MDP has been applied among patients in the emergency room, those with chronic obstructive pulmonary disease, with cardio-respiratory disease and hospitalized patients [13-18]. To our knowledge there are no studies so far that have applied and validated MDP in older adults without focusing on a specific disease.

Older adults have a risk of under-reporting breathlessness as its subjective awareness and severity may be reduced due to the age-related altered sensory perception and breathlessness may also be attributed to normal ageing. [2, 9, 19-23] That is why there is a need for specific validation studies for multidimensional breathlessness assessment tools in this growing age-group.

This study aims to assess the psychometric qualities of the MDP before and after exertion in a sample of adults 75 years and older. We also investigate whether MDP scores differ between participants with different levels of physical performance and affective status.

METHODS

Study Design and Population

This is a cross-sectional study of Belgian adults 75 years and older who were clinically stable and living at their own or in nursing homes. Local nursing homes were invited to participate in the study. The institutions with a positive response provided a list of eligible residents. The inclusion criteria were adults 75 years and older who were clinically stable. Exclusion criteria were acute infection, unstable angina, myocardial infarction in the last month, illiteracy and a physical or cognitive disability that would not allow them to perform the assessment tests of the study. Study participants were randomly selected from the provided lists until 20 participants for institution were reached. A convenience sample of participants living at home was included as well through personal contacts and invitations in two local assisted facilities. We aimed a sample size of approximately 100 participants to fulfil sample size requirements for correlation and factor analysis studies [24]. After selection, each participant was informed about the research and asked to give signed consent. The study was approved by the Ethics Committee of the Katholieke Universiteit Leuven, Leuven, Belgium (mp 18739).

Data collection

The assessment tests were performed in the living environment of the participants and they were randomly assigned to one of the three clinical research assistants who received training to achieve a standardized assessment.

Demographic data were collected (sex, date of birth, type of residence) and height, weight, blood pressure, pulse and peripheral oxygen saturation (SatO₂) were measured for each participant. Then the battery of tests was carried out in the following order: the Hospital Anxiety and Depression Scale (HADS) [25, 26], the Medical Research Council dyspnoea scale (MRC) [27], the modified Borg dyspnoea scale (mBDS) [28], the numerical rating scale for intensity (NRS-I) and unpleasantness

(NRS-U) of breathlessness [10], and the MDP; then the Short Physical Performance Battery (SPPB) [29] was performed followed by a second measurement of blood pressure, pulse and SatO₂ and a second assessment of breathlessness with mBDS, NRS-I, NRS-U and MDP. For the first assessment the participants were asked about their breathlessness at the moment ('right now') and for the second assessment about their breathlessness at the end of exertion ('immediately after the last part of the SPPB').

The SPPB is a battery of physical performance tests to assess the mobility and lower extremity function in older adults that has been widely used and is predictive of adverse outcomes such as mortality, disability and hospitalization [29, 30]. It consists of (1) a standing balance test where the participant stands unassisted with feet together for at least 10 seconds in three positions (side-by-side, semi-tandem and tandem), (2) a walking speed test (measured time of walking 4 meters; the best of two attempts is used and the participant can use their walking aid), and (3) a chair stand test (5 times of standing up from a sitting position in a chair without using the arms) [29]. Each test is assigned up to 4 points, leading to a possible total global performance score of 12, with higher scores indicating higher levels of physical functioning [29].

The MDP was used in the Dutch linguistically validated version available from Mapi Research Trust (www.mapi-trust.org). Additional information about the other scales can be found in Appendix.

Statistical analysis

Baseline characteristics of the sample were analysed with descriptive statistics. MDP was evaluated using the unpleasantness (MDP-A1) score, the Immediate Perception (MDP-IP) score (sum of the A1 score and the total sensory qualities' intensity score), and the Emotional Response (MDP-ER) score (A2 score) at both assessment points.

The factor structure of MDP was analysed with exploratory factor analysis using a varimax rotation. The Kaiser-Meyer-Olkin measure of sample adequacy and Bartlett's test of sphericity were used to

test the suitability of our dataset for factor analysis. Internal consistency of each domain was analysed with Cronbach's alpha. Concurrent validity was assessed with Spearman's correlation coefficients (r) of MDP scores with NRS-I, NRS-U, MRC, mBDS, HADS, SatO₂ and SPPB scores and bootstrapping was used to calculate their 95% confidence intervals (CI).

We used the lowest sex-specific quartile of the SPPB score to define lower physical performance and the highest quartile of anxiety (HADS-A) or depression (HADS-D) HADS scores for lower affective status. The difference of MDP scores between the two groups of physical performance and affective status was tested with the Mann-Whitney U test. Statistical analysis was performed with SPSS 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS

A total of 100 participants were enrolled in the study between 12th of April and 8th of May 2018 (only 4 participants declined to perform SPPB and have the second assessment). The mean age of the participants was 84.94 years (range 75-98) of whom 34% were male and 54 % in nursing homes (Table 1).

Before exertion, participants reported a median MDP-A1 score of 1 (interquartile range (IQR) 0-3); MDP-IP score of 2 (IQR 0-8) and MDP-ER score of 0 (IQR 0-4)(Table 1). Most of the participants (58%) did not choose any of the five sensory qualities of breathlessness provided by MDP, while for the rest 'breathing a lot' was the most frequently chosen sensory quality (14%) followed by 'mental effort or concentration' (13%) (Table 1). At the end of exertion, the most frequent sensory quality was 'muscle effort or work ' (29.2%) followed by 'breathing a lot' (22.9%), while 34.4% still chose none of the five descriptors (Table 1). The MDP scores at the end of exertion were higher than those before exertion, except for the MDP-ER score that was the same (Table 1). The majority of participants chose 0 in the scales for all 5 emotional descriptors at both assessments (before exertion: 84% for depressed, 76% for anxious, 78% for frustrated, 90% for angry and 82% for afraid; at end of exertion: 78% for depressed, 64% for anxious, 76% for frustrated, 82% for angry and 75% for afraid).

The exploratory principal components analysis (with varimax rotation) of the 11 items of MDP identified two principal components that accounted for most of the item variance in the MDP scores (at both assessment points). A1 (unpleasantness) and the five sensory qualities' intensities grouped together (Immediate Perception domain), while the five emotional response intensities grouped separately (Emotional Response domain). All factor loadings were > 0.60 (Table 2). The variance explained by the two factors was 65.37% before and 71.32% at the end of exertion. The Kaiser-Meyer-Olkin measure of sample adequacy (> 0.80) and Bartlett's test of sphericity ($p < 0.001$) confirmed the suitability of our dataset for factor analysis (Table 2).

Internal consistency was moderate to high for MDP-IP score (Cronbach's alpha=0.86 before and 0.89 at end of exertion) and MDP-ER score (Cronbach's alpha= 0.89 before and 0.91 at end of exertion).

Estimates of concurrent validity of the MDP-A1, MDP-IP and MDP-ER scores with NRS-I, NRS-U, MRC, mBDS, HADS, SatO₂ and SPPB scores are presented in Table 3. At both assessment points, MDP scores were significantly correlated with scores of NRS-I, NRS-U, mBDS, MRC and HADS, but not with SatO₂ or SPPB score (except for MDP-IP) (Table 3). Before exertion, MDP-IP had the highest correlations with NRS-U ($r=0.69$, 95% CI 0.56-0.81), NRS-I and mBDS ($r= 0.61$, 95% CI 0.45-0.75), while for MDP-ER the highest correlations were with NRS-U ($r=0.55$, 95% CI 0.38-0.69) and HADS-A ($r=0.52$, 95% CI 0.34; 0.66) (Table 3). At the end of exertion, MDP-IP had the highest significant correlation coefficients with NRS-I ($r= 0.74$, 95% CI 0.62; 0.83) and NRS-U ($r=0.70$, 95% CI 0.56; 0.81), while for MDP-ER the highest correlations were with NRS-U ($r=0.49$, 95% CI 0.32; 0.64) and HADS-A ($r=0.48$; 95% CI 0.32; 0.62) (Table 3). At both assessment points, MDP-IP had a statistically significant negative correlation with the SPPB score ($r= -0.21$ before and -0.27 at end of exertion) (Table 3).

There were no statistically significant differences for MDP-A1, MDP-ER and MDP-IP scores between physical performance groups (those in the lowest sex-specific quartile of the SPPB score v. the rest of the sample) (Figure 1). Before exertion, participants in the highest quartile for HADS-A and HADS-D had significantly higher MDP-A1, MDP-IP and MDP -ER scores compared to the rest of the sample (Figure 1). At the end of exertion, those in the highest quartile of HADS-A had significantly higher MDP-IP and MDP-ER scores, while those in the highest quartile of HADS-D had only a significantly higher MDP-ER score (Figure 1).

DISCUSSION

In our sample of adults 75 years and older who were clinically stable and living either at their own or in a nursing home, MDP showed validity for the multidimensional assessment of breathlessness based on factor structure, reliability and concurrent validity both before and after exertion. MDP scores were statistically different for different affective status groups of participants, but not for different physical performance groups.

To our knowledge, this study is the first to implement and assess the validity of MDP and provide a multidimensional profile of breathlessness before and after exertion in a sample of older adults 75 years and older without focusing on a selected disease. The factor analysis showed a two-factor structure of MDP as in the original MDP study and other MDP validation studies, with the 11 items grouped under immediate perception and emotional response [13, 16, 18]. This two-domain structure was valid at both assessment times. The internal consistency was also moderate to high and similar to previous MDP studies [13, 16, 18].

At both assessments, the MDP-IP and MDP-ER had different patterns of correlations with the other tests. The MDP-IP correlated well with other sensory-perceptual domain measures of breathlessness such as NRS-I, NRS-U and mBDS, but much less with MRC that measures another dimension of breathlessness (impact in functional performance). Measures of breathlessness that assess the sensory-perceptual dimension (NRS-I, NRS-U, mBDS) had higher correlations with MDP-IP than with MDP-ER at both assessment points. HADS-A and HADS-D had higher correlations with MDP-ER than MDP-IP in both assessment points, although in weak-moderate range ($r=0.34-0.52$). These findings are comparable with those of the original MDP validation study [13] as well as MDP studies in other settings [15, 16, 18].

Even though 44% of our study participants rated their breathlessness with the MRC ≥ 3 (moderate-severe), focusing on breathlessness at this moment (before exertion) and at the end of the exertion,

the majority of participants had NRS-I, mBDS and MDP-A1 scores <4 that has been proposed as a cut-off for moderate-severe breathlessness [17]. This discrepancy may be related not only to different tools capturing different dimensions of breathlessness (sensory-perceptual v. functional impact), but also because the present (at rest) and exertion-induced breathlessness are different constructs from breathlessness during activities of daily living [31, 32].

Emotional response to breathlessness

The majority of participants in our study (66% before and 62.5% at end of exertion) rated the intensity for all 5 emotional descriptors as zero. As MDP-A1 scores were low both before and at the end of exertion, participants may have experienced a level of breathlessness intensity that was not strong enough to cause a considerable emotional response towards it, especially in the familiar and supervised environment where the testing took place [16]. The affective/emotional response to breathlessness may vary independently from its intensity and sensation and is determined by the individual affective style (emotional response to unpleasant stimuli) [33, 34]. The MDP aims to capture this affective style [13], yet the affective style of older adults differs from younger ones [20, 35]. Positive emotions may reduce the affective response to breathlessness [36] and older adults are overall more optimistic and have a more positive view of their health than what would be expected based on their morbidity and functional status [20, 35]. Future research needs to explore the possible age-related alteration of the affective response to breathlessness in older adults [20].

At both assessment points, MDP-IP and MDP-ER scores were not significantly different between participants with different levels of physical performance status (based on SPPB score), but they were different between groups of affective status (based on HADS-A and HADS-D scores). These findings suggest that in our sample of older adults the multidimensional profiling of breathlessness was influenced more by the affective status of the participants than their physical performance.

Sensory qualities of breathlessness

In our study, before exertion the majority of participants (58%) could not identify with any of the 5 descriptors provided in the MDP. Yet, at the end of exertion, the majority of participants identified with one of the provided descriptors, mostly with 'muscle effort/work' (29.2%) and 'breathing a lot' (22.9%). These are common sensory qualities of the breathlessness induced through exertion as was the case in our study [10]. For most participants in previous research it has been difficult to provide an exact description of the breathing discomfort that is why providing a list of descriptors to choose from has been helpful [11]. The language used for describing sensory qualities of breathlessness has been studied widely, but it has not been specifically studied in older adults who may provide a different set of sensory qualities especially as breathlessness in older adults is more commonly in a multiple comorbidity setting, multi-factorial and under the influence of age-related blunted perception [2, 3, 19, 20, 22, 35]. Additionally, the linguistic separation between intensity of breathlessness and its unpleasantness is difficult, so assessing the true difference between these two dimensions may be difficult [13, 33, 37, 38]. Our study participants found this difficult as well and even the example of the noise and music was not very helpful for them. This remains an aspect of MDP that could be researched for further refinement.

Multidimensional profiling of breathlessness in older adults

There is a growing consensus that breathlessness needs to be assessed taking into account all its recognized dimensions: sensory/physical, affective and impact in daily life [10, 37]. This would provide a better understanding of its causes and mechanisms, help with the diagnosis as certain sensory qualities are more related to a certain diagnosis, and with management decisions as different available interventions address the sensory and affective dimensions of breathlessness [10, 11, 19, 37].

Previous studies with multidimensional tools for assessment of breathlessness such as MDP have not focused on older adults, but on participants with breathlessness related to a specific disease.

Breathlessness in older adults is mostly present in a multimorbidity setting, is multifactorial, may be influenced by the age-related sarcopenia, blunted perception and potentially altered affective reaction, and has a tendency to be attributed to normal aging [2-4, 7, 19, 20, 22, 23, 35]. These specific features of breathlessness in older adults and its potential as a predictor of adverse outcomes independently from cardio-respiratory diseases call for a more focused research of its multidimensional assessment. MDP maps the sensory-perceptual and affective dimensions of breathlessness and seems to be a valid tool for the multidimensional assessment of breathlessness in older adults. Further research needs to test its validity in larger samples of older adults and consider possible adjustments for its use in this age-group based on a feasibility analysis [39].

Strengths and limitations

This study provides for the first time to our best knowledge data on the performance of the MDP in a sample of older adults without any selection for a specific disease. The standardized comprehensive battery of tests including different breathlessness assessment tools allowed the investigation of concurrent validity of the MDP, but also increased the risk of survey fatigue.

The use of a convenience sample and exclusion criteria are limitations of this study. Despite this, the sample was adequate for running factor analysis and the MDP scores showed consistency before and after exertion and between different levels of physical and affective status. We also lacked information on the morbidity status of our participants that could have provided a more comprehensive profile of their health status. While the SPPB is a recognized and valid tool to assess the physical performance of older adults, it may not have been enough exertion to cause more than a mild level of breathlessness and this may have influenced the findings.

Conclusion

This study confirmed the domain structure, reliability and concurrent validity of MDP for breathlessness before and after a short battery of physical performance tests in a sample of adults 75 years and older in Belgium. These findings support the use and further research of MDP for the multidimensional assessment and profiling of breathlessness in older adults.

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Table 1: Sample characteristics and scores of tests at both assessment points of breathlessness

Measurements	Before exertion (n=100)	At end of exertion (n=96)
Age, years, (mean \pm SD)	84.94 \pm 5.48	
Sex (men), n (%)	34 (34)	
Height , m, (mean \pm SD)	1.64 \pm 0.09	
Weight , kg, (mean \pm SD)	71.98 \pm 13.30	
BMI , kg/m ² , (mean \pm SD)	26.72 \pm 4.20	
Systolic BP, mmHg, (mean \pm SD)	126.40 \pm 25.45	137.63 \pm 20.53
Diastolic BP, mmHg , (mean \pm SD)	74.02 \pm 14.49	79.20 \pm 15.01
SatO ₂ , % , (mean \pm SD)	95.49 \pm 2.61	95.45 \pm 2.89
MDP *		
MDP-A1 score	1 [0, 3]	2 [0, 3]
MDP-IP score	2 [0, 8]	6 [2, 12]
MDP-ER score	0 [0, 4]	0 [0, 4.75]
Sensory qualities		
Other	Best match, n (%)	
	Intensity	
Muscle effort/work	9 (9) 0 [0, 0.75]	28 (29.2) 1 [0, 4]
Air hunger	2 (2) 0 [0, 0]	2 (2.1) 0 [0,0]
Chest tightness	4 (4) 0 [0, 0]	4 (4.2) 0 [0, 0]
Mental effort/concentration	13 (13) 0 [0, 0]	7 (7.3) 0 [0, 1]
Breathing a lot	14 (14) 0 [0, 1]	22 (22.9) 0 [0, 3.75]
Sensory qualities intensity total score	0 [0, 6.75]	4 [0, 10]
Emotional responses		
Depressed	0 [0, 0]	0 [0, 0]
Anxious	0 [0, 0]	0 [0, 2]
Frustrated	0 [0, 0]	0 [0, 0]
Angry	0 [0, 0]	0 [0, 0]
Afraid	0 [0, 0]	0 [0, 0]
NRS * Intensity	0 [0, 4]	2 [0, 4]
Unpleasantness	1 [0, 4]	2 [0, 4]
mBDS *	0.5 [0, 3]	2 [0.5, 3]
MRC, n (%)		
0 (no breathlessness at all)	14 (14)	
1 (short of breath only in strenuous exercise)	23 (23)	
2 (short of breath when hurrying on level/ walking up a slight hill)	19 (19)	
3 (walks slower than peers on level due to shortness of breath/stops for breath after walking at own space)	8 (8)	

4 (stops for breath after walking 100 meters/few minutes in level ground)	18 (18)	
5 (too breathless to leave the house or when un/dressing)	18 (18)	
HADS Total	13 [7,16]	
Anxiety	6 [3, 9]	
Depression	6 [3.25, 8]	
SPPB		5 [3, 8]

Data presented as median [interquartile range], unless otherwise specified. SD: standard deviation; BMI: Body Mass Index; BP: Blood Pressure; SatO₂: peripheral oxygen saturation; MDP: Multidimensional Dyspnoea Profile; MDP-A1: Unpleasantness/Discomfort, MDP-IP: Immediate Perception, MDP-ER: Emotional Response; MRC: Medical Research Council dyspnoea scale; NRS: Numerical Rating Scale; mBDS: modified Borg dyspnoea scale; HADS: Hospital Anxiety and Depression Scale; SPPB: Short Physical Performance Battery. **number of participants with scores > 0 as follows: MDP-A1 54 before and 69 after exertion; MDP-IP 34 before and 36 after; MDP-ER 65 before and 78 after; NRS-I 48 before and 66 after; NRS-U 54 before and after; mBDS 63 before and 75 after.*

Table 2: Exploratory Principal Components Analysis of MDP before and at end exertion

MDP Items	Rotated Factor Loadings			
	Before exertion (<i>"At this moment"</i>)		After exertion (<i>"At the end of last part of SPPB"</i>)	
	Factor 1	Factor 2	Factor 1	Factor 2
Unpleasantness	0.67	0.36	0.79	0.17
Muscle work or effort	0.78	0.15	0.66	0.40
Air hunger	0.84	0.09	0.88	0.23
Chest tightness/ constriction	0.65	0.40	0.78	0.40
Mental effort/concentration	0.65	0.29	0.74	0.39
Breathing a lot	0.75	0.33	0.69	0.26
Depressed	0.25	0.83	0.32	0.78
Anxious	0.35	0.71	0.35	0.74
Frustrated	0.46	0.79	0.39	0.83
Angry	0.11	0.81	0.18	0.85
Afraid	0.22	0.77	0.28	0.82
KMO	0.84		0.89	
Bartlett's test of sphericity	<0.001		<0.001	

MDP: Multidimensional Dyspnoea Profile; SPPB: Short Physical Performance Battery; KMO: Kaiser-Meyer-Olkin measure of sample adequacy

Table 3: Correlations of MDP scores with other breathlessness measures, HADS, SatO₂ and SPPB before and at the end of exertion

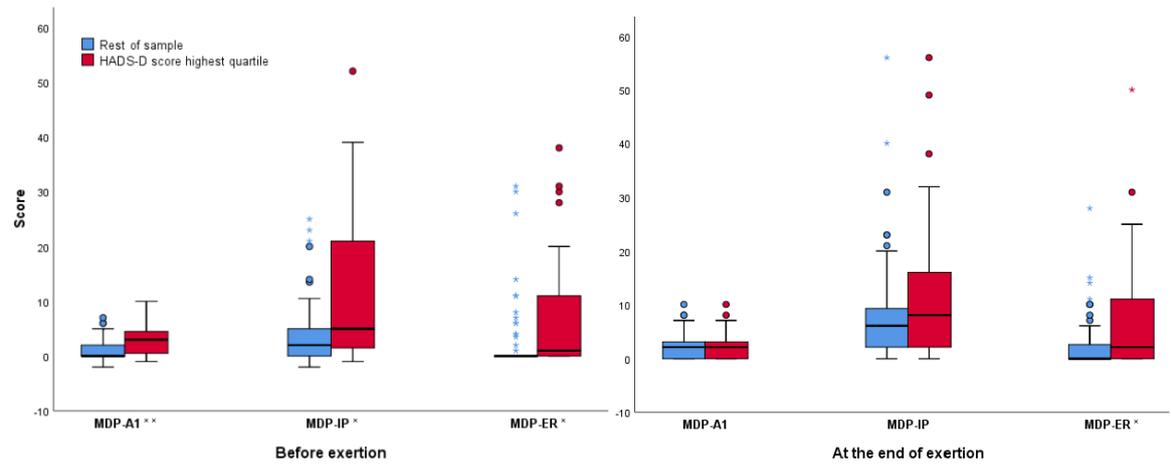
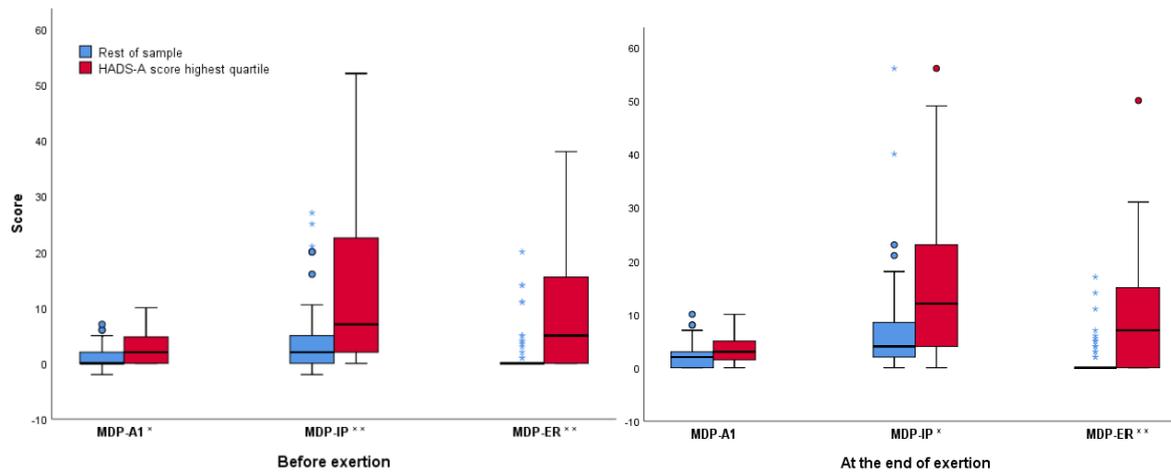
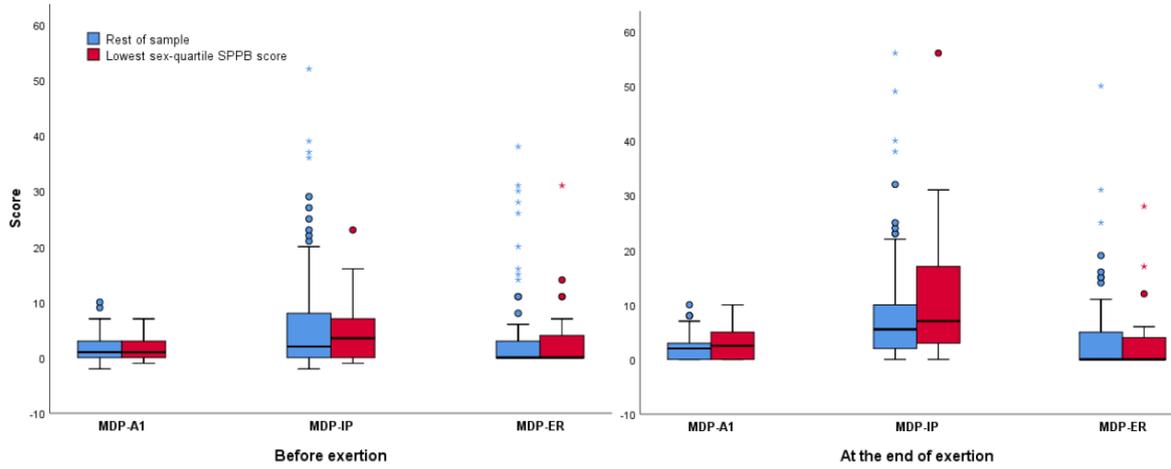
Other assessments	Before exertion			At the end of exertion		
	MDP A1	MDP IP	MDP ER	MDP A1	MDP IP	MDP ER
NRS-I	0.74 (0.60; 0.85)	0.61 (0.45; 0.75)	0.44 (0.27; 0.60)	0.74 (0.59; 0.85)	0.74 (0.62; 0.83)	0.41 (0.23; 0.58)
NRS-U	0.75 (0.62; 0.85)	0.69 (0.56; 0.81)	0.55 (0.38; 0.69)	0.79 (0.66; 0.88)	0.70 (0.56; 0.81)	0.49 (0.32; 0.64)
MRC	0.25 (0.04; 0.45)	0.40 (0.21; 0.57)	0.35 (0.16; 0.52)	0.37 (0.16; 0.55)	0.47 (0.27; 0.63)	0.22 (0.01; 0.41)
mBDS	0.58 (0.40; 0.72)	0.61 (0.45; 0.75)	0.44 (0.24; 0.61)	0.66 (0.51; 0.78)	0.60 (0.44; 0.73)	0.30 (0.12; 0.48)
HADS-A	0.48 (0.31; 0.63)	0.44 (0.27; 0.60)	0.52 (0.34; 0.66)	0.31 (0.09; 0.49)	0.34 (0.13; 0.54)	0.48 (0.32; 0.62)
HADS-D	0.32 (0.11; 0.51)	0.37 (0.16; 0.54)	0.36 (0.17; 0.52)	0.11 (-0.11; 0.31)	0.27 (0.05; 0.45)	0.34 (0.15; 0.50)
SatO ₂	0.12 (-0.32; 0.09)	-0.13 (-0.32; 0.06)	-0.12 (-0.30; 0.08)	-0.06 (-0.27; 0.16)	-0.09 (-0.30; 0.11)	-0.02 (-0.25; 0.18)
SPPB	-0.17 (-0.36; 0.02)	-0.21 (-0.40; -0.02)	-0.19 (-0.37; 0.003)	-0.14 (-0.33; 0.08)	-0.27 (-0.45; -0.09)	-0.18 (-0.37; 0.01)

Spearman correlation coefficient (95% Confidence Interval)

MDP: Multidimensional Dyspnoea Profile; A1: unpleasantness; IP: Immediate Perception; ER: Emotional Response NRS: Numerical Rating Scale; I: Intensity; U: unpleasantness; MRC: Medical Research Council dyspnoea scale; mBDS: modified Borg dyspnoea scale; HADS: Hospital Anxiety and Depression Scale; A: Anxiety; D: depression; SatO₂: peripheral oxygen saturation; SPPB: Short Physical Performance Battery.

Figure 1: MDP scores before and at the end of exertion for different performance groups of SPPB, HADS-A and HADS-D. The boxes represent the interquartile range of the scores. The black horizontal line in each box represents the median score and the whiskers the minimum and maximum scores. Outliers are presented by circles and extreme outliers by asterisks.

MDP: Multidimensional Dyspnoea Profile; IP: Immediate Perception; ER: Emotional Response; A1: unpleasantness; HADS: Hospital Anxiety and Depression Scale; A: Anxiety; D: Depression; SPPB: short physical performance battery; Statistical significance of the difference tested with Mann-Whitney U test. * p-value <0.05, ** p-value <0.001



Appendix

Questionnaires/Scales used in the study protocol

1. **Hospital Anxiety and Depression Scale** (Dutch version from <https://meetinstrumentenzorg.nl/wp-content/uploads/instrumenten/HADS-meetinstr-KNGF-2018.pdf>) Responses of participants to 14 questions on how they have been feeling recently (past 4 weeks). Items 1,3,5,7,9,11 and 13 relate to anxiety and items 2,4,6,8,10 and 14 relate to depression. Each is rated on four possible point categories (0–3) with scores ranging from 0 to 21 for each subscale. Scores ≥ 8 for each subscale indicate presence of either anxiety or depression.

1.I have been feeling tense lately	0 Not at all 1 From time to time , occasionally 2 A lot of the time 3 Most of the time
2.I still enjoy the things I used to enjoy	0 Definitely as much 1 Not quite so much 2 Only a little 3 Hardly at all
3.I get a sort of frightened feeling lately as if something awful is about to happen	0 Not at all 1 A little, but it doesn't worry me 2 Yes, but not too badly 3 Very definitely and quite badly
4.I can laugh and see the funny side of things	0 As much as I always could 1 Not quite so much now 2 Definitely not so much now 3 Not at all
5.I have been worrying lately	0 Only occasionally 1 From time to time but not too often 2 Often 3 Very often
6.I have been feeling cheerful lately	0 Most of the time 1 Sometimes 2 Not often 3 Not at all
7.I have been able to sit and relax lately	0 Definitely 1 Usually 2 Not often 3 Not at all
8. I feel as if I am slowed down lately	0 Not at all 1 Sometimes 2 Very often 3 Almost always
9. I get a sort of frightened feeling like	0 Not at all

'butterflies' in the stomach lately	1 Occasionally 2 Quite often 3 Very often
10. I have lost interest in my appearance lately	0 I take just as much care as ever 1 I may not take quite as much care 2 I don't take as much care as I should 3 Definitely
11. I feel restless lately	0 Not at all 1 Not very much 2 Quite a lot 3 Very much indeed
12. I look forward with enjoyment to things	0 As much as I ever did 1 Rather less than I used to 2 Definitely less than I used to 3 Hardly at all
13. I get sudden feelings of panic lately	0 Not at all 1 Not very often 2 Quite often 3 Very often indeed
14. I can enjoy a good book or radio or TV program	0 Often 1 Sometimes 2 Not often 3 Very seldom

2. Medical Research Council dyspnoea scale (Dutch version from CAHAG at <https://www.cahag.nl/sites/default/files/2018-10/MRC%20Score.pdf>)

0	Not troubled by breathlessness at all
1	Not troubled by breathless except on strenuous exercise
2	Short of breath when hurrying on a level or when walking up a slight hill
3	Walks slower than people of the same age on the level because of breathlessness or have to stop for breath when walking at own pace on the level ground
4	Stops for breath after walking 100 m, or after a few minutes on level ground
5	Too breathless to leave the house, or breathless when dressing/undressing

3. modified Borg dyspnoea scale (Dutch version from www.kngfrichtlijnen.nl)

How difficult is your breathing in this moment?

0	No short of breath at all
0.5	Hardly short of breath
1	Very slight
2	Slight
3	Moderate
4	Somewhat severe
5	Severe
6	
7	Very severe
8	
9	
10	No breath at all

4. Numerical Rating Scale for Intensity and Unpleasantness of dyspnoea

Participants were asked to rate the intensity and unpleasantness of their breathlessness in a scale of 1 to 10, where 1 is no intensity/unpleasantness at all and 10 is very much intensity/unpleasantness.

5. Multidimensional Dyspnoea Profile (Dutch version available from MAPI Research Trust www.mapi-trust.org)

Multidimensional Dyspnea Profile page 1 of 4 name/code _____ date&time

MULTIDIMENSIONAL DYSPNEA PROFILE

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Script for first time use:

The purpose of this questionnaire is to help us understand how your breathing feels. There are no right or wrong answers. We want to know what you tell us about your own breathing. On this page we ask you to tell us how unpleasant your breathing feels. On a later page we will ask you about the intensity or strength of your breathing sensations. The distinction between these two aspects of breathing sensation might be made clearer if you think of listening to a sound, such as a radio. As the volume of the sound increases, I can ask you how loud it sounds or how unpleasant it is to hear it. For example, music that you hate can be unpleasant even when the volume is low, and will become more unpleasant as the volume increases; music that you like will not be unpleasant, even when the volume increases.

A1 Scale

Use this scale to rate the **unpleasantness or discomfort** of your breathing sensations, how **bad** your breathing feels.

Please focus on this moment.

← ← 0 1 2 3 4 5 6 7 8 9 10
PLEASANT NEUTRAL UNBEARABLE

Multidimensional Dyspnea Profile page 2 of 4 name/code _____ date&time

Sensory Qualities choice

Below are phrases or terms arranged in groups of similar meaning.

Step 1: Check each group that describes how your breathing feels in this moment.

Step 2: Please also mark *one* group that most accurately describes how your breathing feels in this moment.

If <i>ANY</i> term in the group applies, choose that group.	Step 1		Step 2
	DOES NOT APPLY	DOES APPLY	MOST ACCURATELY DESCRIBES
My breathing requires muscle work <i>or</i> effort			
I am not getting enough air <i>or</i> I am smothering <i>or</i> I feel hunger for air			
My chest and lungs feel tight <i>or</i> constricted			
My breathing requires mental effort <i>or</i> concentration			
I am breathing a lot			

Sensory Qualities Scales

Use these scales to rate the intensity of the breathing sensations you feel [felt] (like the loudness of sound, regardless of whether the sensation is pleasant or unpleasant; for example a sensation could be intense without being unpleasant.) Please focus on this moment.

If <i>ANY</i> term in the group applies, rate that group.	AS INTENSE AS I CAN IMAGINE											
	NONE											
My breathing requires muscle work <i>or</i> effort	0	1	2	3	4	5	6	7	8	9	10	
I am not getting enough air <i>or</i> I am smothering <i>or</i> I feel hunger for air	0	1	2	3	4	5	6	7	8	9	10	
My chest and lungs feel tight <i>or</i> constricted	0	1	2	3	4	5	6	7	8	9	10	
My breathing requires mental effort <i>or</i> concentration	0	1	2	3	4	5	6	7	8	9	10	
I am breathing a lot	0	1	2	3	4	5	6	7	8	9	10	
Other*	0	1	2	3	4	5	6	7	8	9	10	

*If you need to, you can add additional descriptions of your breathing sensations.

A2 Scales

When your breathing doesn't feel normal, you may experience emotions or 'feelings'. Using the scales below, please tell us about how your breathing sensations made you feel – rate zero for any emotion you did not feel.

Please focus on feelings in this moment.

	NONE											THE MOST I CAN IMAGINE
Depressed	0	1	2	3	4	5	6	7	8	9	10	
Anxious	0	1	2	3	4	5	6	7	8	9	10	
Frustrated	0	1	2	3	4	5	6	7	8	9	10	
Angry	0	1	2	3	4	5	6	7	8	9	10	
Afraid	0	1	2	3	4	5	6	7	8	9	10	
Other?	0	1	2	3	4	5	6	7	8	9	10	