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Reliability of verbal descriptors of dyspnea and their relationship with perceived intensity and unpleasantness

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ABSTRACT. Verbal descriptors of dyspnea have been suggested as being useful in providing information on the underlying pathophysiology. However, little is known about the reliability of these descriptors. The present study examined the reliability of a German language list of respiratory symptom descriptors and studied the association of these descriptors with the intensity and unpleasantness of perceived dyspnea. Fourteen healthy volunteers performed cycle-ergometer exercise and voluntary breath-holding during which they rated the perceived intensity (VAS-I) and unpleasantness (VAS-U) of dyspnea on visual analog scales. Following this, they judged their sensations of dyspnea using the list of symptom descriptors. Both conditions were repeated in reverse order on a subsequent occasion 10 days apart. Ventilatory measures, heart rate, blood lactate, VAS-I and VAS-U during cycle-exercise as well as breath-holding time, VAS-I and VAS-U during breath-holding showed no differences between both occasions. Separate hierarchical cluster analyses identified four clusters of verbal descriptors of dyspnea which were widely comparable between both occasions: effort, speed, obstruction and suffocation. Separate multidimensional scaling analyses (MDS) confirmed these four clusters for each occasion. On both days, perceived unpleasantness of dyspnea was correlated with all four clusters during cycle-exercise, while perceived intensity showed only correlations with effort or speed, respectively. No such correlations were obtained for breath-holding. The results suggest that separable clusters of German language descriptors of dyspnea are reliably used by healthy volunteers. The obtained clusters are widely comparable to previously described clusters in other languages and are differently related to the intensity and unpleasantness of perceived dyspnea.

Key words: dyspnea, perception, verbal descriptors, diagnosis.

RIASSUNTO. I descrittori verbali della dispnea sono stati indicati utili nel provvedere informazioni circa la sottostante pato-fisiologia. Tuttavia poco si conosce circa la affidabilità (reliability) dei suddetti descrittori. Lo studio esamina la affidabilità di descrittori di sintomi respiratori, in lingua tedesca, e ne studia l'associazione con la percezione di intensità e di spiacevolezza della dispnea. Quattordici volontari sani si sono sottoposti a esercizio al cicloergometro e alla sospensione transitoria dell'atto respiratorio (apnea). Ad ogni soggetto veniva chiesto di indicare su analogo visivo, l'intensità (VAS-I) e la spiacevolezza (VAS-U) della dispnea percepita. A seguire veniva richiesto di giudicare la sensazione di dispnea valendosi della lista dei descrittori dei sintomi. A distanza di dieci giorni, entrambe le condizioni venivano poi ripetute in ordine inverso. Le misure ventilatorie, di frequenza cardiaca, VAS-I e VAS U sia durante ciclo di esercizi sia nella fase di trattenimento del respiro, non hanno evidenziato differenze. Le analisi di cluster gerarchiche hanno identificato quattro cluster di descrittori verbali di dispnea che erano ampiamente comparabili tra le situazioni: sforzo, velocità, ostruzione e soffocamento. Le analisi di scaling multidimensionale (MDS) hanno confermato i suddetti 4 cluster per ciascuna occasione. In entrambi i giorni, la percepita spiacevolezza della dispnea è risultata correlare con ciascuno dei quattro cluster durante il ciclo di esercizi, mentre la intensità percepita ha mostrato solo correlazioni rispettivamente con lo sforzo o con la velocità. Nessuna correlazione è stata riscontrata con il respiro trattenuto. I risultati suggeriscono che cluster separati di descrittori di dispnea sono affidabilmente utilizzati da volontari sani. I cluster ottenuti sono ampiamente comparabili a precedenti cluster riscontrati in altre lingue e sono differenzialmente connesse a intensità e spiacevolezza della dispnea percepita.

Parole chiave: dispnea; percezione; descrittori verbali; diagnosi.

Introduction

Dyspnea or breathlessness is an impairing symptom in asthma, COPD and various other cardiovascular or neuromuscular diseases as well as psychological disorders and is associated with severe disability and reductions in quality of life (1-3). Dyspnea is defined as the subjective experience of uncomfortable breathing comprising distinct sensations which can vary in their quality and intensity (1). Hence, it is not a single sensation but rather a multidimensional construct which is also reflected in the language persons use to describe the experienced sensation. Verbal descriptors of dyspnea have therefore been suggested as being useful in providing clinically important diagnostic information on the underlying pathophysiology which might be of further relevance for choosing the optimal treatment of this impairing symptom (4-6).

Recent research on the perception of breathlessness has demonstrated that the feeling of dyspnea consists of at least two primary elements: the sense of work/effort and the feeling of air hunger (1, 7, 8). A number of studies have tried to refine the understanding of these two qualitatively different sensations in healthy persons as well as in different patient groups. Three (6, 9) up to ten (10) distinguishable types of dyspnea have been suggested and partly been linked to specific underlying disease conditions. For example, Simons and colleagues (5) showed that patients with asthma use the terms chest tightness, concentration and exhalation to describe their feelings of dyspnea while patients with COPD preferred the terms hunger, gasping and effort (5). However, little is known to date about the reliability of these descriptors.

Moreover, in analogy to investigations on pain, previous research has demonstrated that the perception of dyspnea also consists of at least two distinct dimensions: a sensory (i.e., intensity) and an affective (i.e., unpleasantness) one. These dimensions can be differentiated during resistive load breathing (11, 12), physical exercise tests (13, 14) or in real life settings (15, 16) by healthy volunteers and by patients with asthma or COPD. How verbal descriptors of dyspnea are related to these dimensions has, however, not been examined yet.

Therefore, the present study examined the reliability of a previously developed German language list of 20 respi-

ratory symptom descriptors adapted from Simon et al. (4) in healthy volunteers who underwent cycle-ergometer exercise and voluntary breath-holding on two separate occasions. Furthermore, the relationship of these descriptors with the intensity and unpleasantness of perceived dyspnea was studied.

Methods

Participants

Fourteen healthy volunteers (6 female, mean age = 26.9 years, SD = 4.9) were studied.

Their mean baseline characteristics are summarized in Table I. Acute complaints of the respiratory tract, cardiac failure, pregnancy or any chronic medical conditions, such as asthma or chronic pain were exclusion criteria. After providing informed written consent volunteers underwent a screening spirometry and a resting ECG supervised by a physician. Participants were free to withdraw at any time during the tests. The study protocol was in accordance with the recommendations of the Helsinki Declaration (17).

Cycle-ergometer exercise

Participants performed incremental cycle-ergometer exercise on an electronically braked ergometer (Excalibur Sport, Lode, Groningen, the Netherlands) to maximum workload with a 25W load increase every 2 min according to the WHO scheme. Tidal volume (V_T), minute volume (MV) and breathing frequency (f) were continuously measured with a Metamax spiroergometric system (Cortex Biophysik GmbH, Leipzig, Germany), while heart rate (HR) was continuously monitored with a Polar T 31 heart rate monitor (Büttelborn, Germany). Blood lactate (BL) was sampled at the end of each workload level and analyzed with a lactate analyzing unit applying the enzymatic-amperometric method (Biosen C line, EKF diagnostic GmbH, Barleben, Germany).

Breath-holding

Participants performed voluntary breath-holding in a sitting position by breathing via a mouthpiece through a breathing circuit with the nose occluded by a clip. After a deep inspiration (i.e., at inspiratory capacity), a shutter was closed which interrupted ventilation. Participants opened the shutter by themselves when dyspnea became intolerable. Breath-holding time (T_B) was measured by an experimenter who, for safety reasons, also stopped breath-holding after 2 minutes.

Measurement of perceived dyspnea

Dyspnea was defined as the sensation of uncomfortable restricted breathing with the connotation that all other sensations (e.g., uncomfortable nose clip or tired legs) are not to be rated. After each experimental condition the experienced degree of intensity (= sensory) and unpleasantness (= affective) was rated on separate visual analog scales (VAS) (18) ranging from 0-10 cm (0 = not noticeable/unpleasant and 10 = maximally imaginable intensity/

unpleasant). VAS for intensity (VAS-I) and unpleasantness (VAS-U) were presented in randomised order. The distinct dimensions of perceived dyspnea were explained in detail with standardized examples and the experimenter made sure that the phrases were adequately understood.

A previously developed German language list of 20 respiratory symptom descriptors adapted from Simon et al. (4, 5) (Table II) was presented after the experimental conditions. Each descriptor was rated on a 5-point scale, ranging from 0 (= not at all) to 4 (= very strong). In addition to items used in the English original, we added two items that were more specific to German language expression of respiratory discomfort that can be translated as: "I am running out of air" and "I am panting for more air". In contrast to the English version the German list included only one item describing suffocation directly, because in the German language there is no distinction between smothering and suffocation.

Experimental Protocol

Before the tests participants were familiarized with all instruments and measurement procedures. In half of the participants this was followed by the cycle-ergometer exercise, in the other half by the voluntary breath-holding test. The experienced respiratory sensations were rated on the verbal descriptor list after each experimental condition, preceded by the visual analog scale ratings of intensity and unpleasantness of dyspnea. After a variable relaxation period the second experimental condition followed with ratings being provided in the same fashion. The same experimental protocol was repeated on a second occasion 10 days later, with cycle-ergometer exercise and breath-holding being presented in reversed order. After the second occasion participants were debriefed.

Statistical Analysis

Results are reported as means \pm standard deviations of the mean (SD). To compare the intensity of cycle-exercise and breath-holding between the two occasions, V_T , MV, f , HR, BL, T_B , VAS-I and VAS-U were analysed with separate one-way analyses of variance (ANOVA) (occasion 1 vs. occasion 2).

Two different multivariate methods were used for the analysis of the verbal descriptors (separately for each of the two occasions): hierarchical cluster analysis and ordinal multidimensional scaling (MDS). Both are explorative methods analyzing the relationship of objects on the basis of their mutual similarities or distances with regard to various attributes. For both methods, a distance matrix was computed indicating the distance of each item to each of the other items. Both conditions (cycle-exercise, breath-holding) served as "attributes" and the distances were computed with reference to the ratings of the two conditions simultaneously. The aim of cluster analysis is to find homogeneous subgroups of items in the heterogeneous list of descriptors on the basis of the distance matrix. In the present study the Single Linkage algorithm with squared euclidian distances was used and results were confirmed by other fusion algorithms such as Ward and Complete Linkage which can be regarded as a stable cluster solution.

MDS displays the configuration of the items in a multidimensional space on the basis of the square distance matrix. The goal of MDS is to reveal the dimensions that build a perceptual space and the position of each item in this space. The difference between these two very similar methods is that MDS reveals continuous dimensions that underlie the similarities of objects, whereas cluster analysis displays the degree of similarities between the objects more precisely and combines them into distinct subgroups.

The association of perceived intensity and unpleasantness of dyspnea with clusters of descriptors was analyzed by computing rank correlations (Spearman rho, one-tailed) between VAS-I and VAS-U and the clusters, separately for each occasion. All analyses were calculated with SPSS 11.5 software (SPSS Inc., Chicago, IL) using a .05 significance level.

Results

ANOVAS showed that the intensity of cycle-exercise and breath-holding was comparable between occasion 1 and 2, i.e. no differences in V_T , MV, f, HR, BL, T_B , VAS-I's and VAS-U's were obtained.

Separate hierarchical cluster analyses identified four clusters of verbal descriptors of dyspnea which were widely comparable between both occasions and which we interpreted as: 1. effort, 2. speed, 3. obstruction and 4. suffo-

Table I. Baseline Characteristics of Participants

Characteristics	Data
Age (yr)	26.9 (4.9)
Sex (female/male)*	6/8
Weight (kg)	73.2 (12.2)
Height (cm)	174.5 (2.2)
FEV ₁ (L)	3.99 (0.68)
FEV ₁ (% predicted)	101.5 (11.7)

* Values are given as No., all other data are presented as mean + (SD).

cation (Table II). Cluster 1 and 2 as well as cluster 3 and 4 defined two super ordinate clusters: work of breathing and air hunger. However, some descriptors were not located in the same cluster at the second occasion but remained in the super ordinate clusters (grey descriptors in Table II, white and black squares in Figure 1). Only three descriptors were not located in the same super ordinate clusters (bold descriptors in Table II; crosses in Figure 1).

MDS identified two dimensions for both occasions which we interpreted as: work of breathing and air hunger. As a measure of fit Kruskal Stress was used. The two dimensional configuration reached a Stress value of <.005 indicating an excellent fit of the chosen configuration to the data (19). The grouping of descriptors along these dimensions was widely comparable to the results of the clus-

Table II. Schematic overview of the results of the hierarchical cluster analyses and correlation analyses*

Cluster	Descriptors at occasion 1	ρ -VAS-U Cycle-Exercise	ρ -VAS-I Cycle-Exercise	Descriptors at occasion 2	ρ -VAS-U Cycle-Exercise	ρ -VAS-I Cycle-Exercise
Work	Effort My breathing is heavy. My breathing requires more work. My breathing requires more effort. I feel out of breath.	.51 (p=.032)	.55 (p=.021)	My breathing is heavy. My breathing requires more work. My breathing requires more effort. I feel out of breath.	.57 (p=.017)	.45 (p=.052)
	Speed I feel that I am breathing more. I feel that my breathing is rapid. My breathing is shallow.	.56 (p=.019)	.56 (p=.019)	I feel that I am breathing more. I feel that my breathing is rapid. My breathing is shallow.	.44 (p=.059)	.34 (p=.119)
Air Hunger	Obstruction I am gasping for breath. My chest feels tight. My breath does not go in all the way. My chest is constricted. I feel that my breath stops.	.52 (p=.03)	.38 (p=.09)	I am gasping for breath. My chest feels tight. My breath does not go in all the way. My chest is constricted. I feel that my breath stops.	.53 (p=.023)	.32 (p=.13)
	Suffocation I feel a hunger for more air. I can not get enough air. I can not take a deep breath. My breathing requires more concentration. I am panting for more air. I feel that I am suffocating. I am running out of air. My breath does not go out all the way.	.47 (p=.045)	.39 (p=.085)	I feel a hunger for more air. I can not get enough air. I can not take a deep breath. My breathing requires more concentration. I am panting for more air. I feel that I am suffocating. I am running out of air. My breath does not go out all the way.	.57 (p=.018)	.33 (p=.128)

* Spearman rho correlations (ρ , one-tailed) between the mean of the item responses of descriptors in each cluster with the VAS ratings of unpleasantness (VAS-U) and intensity (VAS-I) during cycle-exercise for occasion 1 and 2. Four descriptors were not located in the same cluster at the second occasion but remained in the super ordinate clusters (grey descriptors). Only three descriptors were not located in the same super ordinate clusters (bold descriptors).

Verbal descriptors of Dyspnea

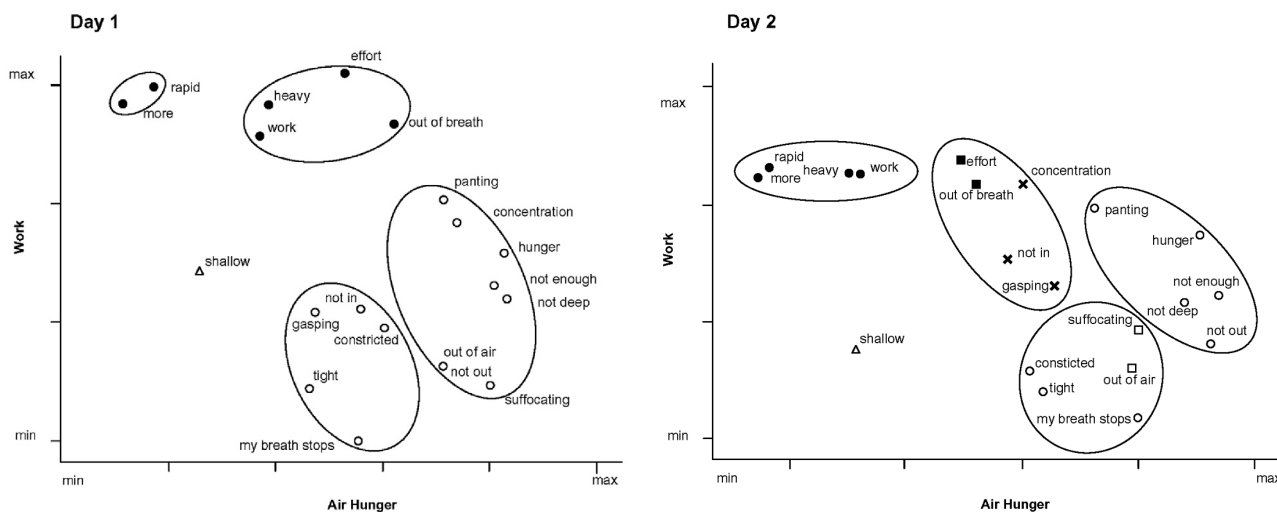


Figure 1. MDS configuration of descriptors along the dimensions of work and air hunger for the first occasion (left panel) and second occasion (right panel). Black colour indicates descriptors of the super ordinate cluster work of breathing. White colour indicates descriptors of the super ordinate cluster air hunger. White and black squares indicate descriptors migrating between sub clusters within one superordinated cluster, crosses indicate descriptors migrating between the super ordinate clusters, triangles indicate outlying descriptor in MDS

ter analyses. We displayed the results of MDS and cluster analysis as a joint representation in Figure 1. However, one descriptor (“shallow breathing”) was outlying on both occasions.

On both days, perceived unpleasantness of dyspnea showed significant correlations with all four clusters during cycle-exercise, while perceived intensity was only correlated with effort or speed, respectively (Table II). No such correlations were obtained for breath-holding.

Discussion

In the present study dyspnea was successfully induced in healthy participants by cycle-exercise and breath-holding on two separate days. The intensity of both conditions was comparable between occasions since no differences in physiologic parameters (tidal volume, minute volume, breathing frequency, heart rate and blood lactate) as well as breath-holding time and perceived intensity and unpleasantness of dyspnea were obtained. Results of the hierarchical cluster analyses and the multidimensional scaling showed that four clusters of verbal descriptors of dyspnea could be differentiated by the participants: effort, speed, obstruction and suffocation. The clusters effort and speed as well as the clusters obstruction and suffocation defined two super ordinate clusters: work of breathing and air hunger which is in line with previous findings (1, 7, 8). Perceived unpleasantness of dyspnea showed significant correlations with all four clusters during cycle-exercise, while perceived intensity was only correlated with effort or speed, respectively. In contrast, no such correlations were obtained for breath-holding. Most important for the present study was the finding that these four clusters were widely comparable between both occasions, suggesting

that separable clusters of German language descriptors of dyspnea are reliably used by healthy volunteers.

This confirms findings of two recent studies which also reported satisfying test-retest reliabilities of descriptors of respiratory sensations. However, both studies are not directly comparable to the present results. The study by Mahler et al. (10) examined whether patients with COPD choose the same descriptors for their respiratory sensations at rest on two occasions (i.e., recall). Furthermore, they compared the use of descriptors for recalled sensations with the use of descriptors during moderate physical activity. The results showed a 79% agreement of recalled sensations between both occasions and a 68% agreement between recall at rest and physical activity on the second occasion. Since no experimental induction of dyspnea was performed on both occasions to test the reliability of selected descriptors, memory effects might have influenced the obtained results rather than specific physiologic signals. Also Han and colleagues (20) reported a satisfying test-retest reliability of Chinese language symptom descriptors. However, the authors reported only an interval of at least 2 hours between the two ratings which prevents conclusions on the long-term stability of the ratings. Since no acute dyspnea was induced in the study, memory effects might have also influenced the results.

The obtained clusters of descriptors in the present study converge with a number of previous findings. For example, effort of breathing was also obtained in several studies, e.g. Simon et al. (4, 5), Harver et al. (6) and Mahler et al. (10). The speed cluster identified in the present study seems comparable to the fusion of the descriptor “My breathing is rapid” and “I am breathing more” in the studies by Harver et al. (6) and Mahler et al. (10) on a higher fusion level (see respective dendrograms), and also to the factor “rapid breath” in the study of Perna et al. (9)

which combines the descriptors "My breathing is rapid" and "My breathing is shallow". Moreover, the clusters obstruction and suffocation, have also been demonstrated in previous studies (4-6, 21).

An obvious difference between our study and former investigations is the small number of clusters we are restricting ourselves to. In contrast to stopping at a lower fusion level and reporting clusters of only one or two items, we decided to interpret a four cluster solution with rather super ordinate clusters. The rationale of this strategy was based on the finding that these four clusters merge to the two super ordinate clusters "work of breathing" and "air hunger" which have been assumed to be the two primary elements of dyspnea (1, 7, 8). Moreover, these four clusters might mirror recent hypotheses on the underlying physiologic mechanisms for the generation of dyspnea (22, 23). Following this lead, obstruction might be more related to bronchoconstriction and stimulation of pulmonary receptors while suffocation might be closer associated with the stimulation of chemoreceptors (8, 21, 24). Increased effort has been assumed to be related to increased load of the respiratory muscles, stimulation of mechanoreceptors in the chest wall and increased motor command while the speed of breathing could be related to increased motor command or sensory pulmonary or upper airway receptors (24). However, different physiologic pathways might also add or succeed to others and an afferent mismatch, i.e., a dissociation between efferent motor command to the respiratory muscles and afferent feedbacks from pulmonary and chest wall receptors, might be involved in many forms of dyspnea (24). In general, there is no agreement on the specific number of distinct dyspneic sensations resulting in a considerable variety of obtained clusters across studies (25). Therefore, even the number of descriptors within each cluster varies across studies. This might in part be related to the experimental situations during which descriptors were to be rated (e.g., different forms of exercise, hypercapnia, memory). These different contexts might have triggered different physiologic or even psychological pathways and thus have resulted in differences in verbal descriptions.

However, not all descriptors in the present study demonstrated perfect reliability. For example "My breathing requires more effort." and "I feel out of breath." were in the effort cluster on the first, but in the speed cluster on the second occasion. The same holds for the descriptors "I feel that I am suffocating." and "I am running out of air." which were located in the obstruction cluster on the first, but in the suffocation cluster on the second occasion. This might have been caused by their location at the boundaries of the clusters. All four descriptors were, however, located in the same super ordinate cluster work of breathing or air hunger respectively which suggests at least a reliable differentiation of these descriptors between the primary elements of dyspnea. Three descriptors ("My breathing requires more concentration.", "My breath does not go in all the way." and "I am gasping for breath.") migrated between the super ordinate clusters between the two occasions suggesting a limited reliability of these items. This overlaps with findings from Simons et al. (5) who also excluded the items "My

breathing requires more concentration." and "I am gasping for breath." as outliers from further analyses. However, future studies are required to establish whether these descriptors show a comparable low reliability in dyspneic patients groups using German language and thus might be excluded in future versions of the descriptor list.

The present study further demonstrated that on both occasions the perceived unpleasantness of dyspnea showed significant correlations with all four clusters of verbal descriptors during cycle-exercise, while perceived intensity was only correlated with effort or speed, respectively. This suggests, that all four clusters of verbal descriptors express to some degree the unpleasant (affective) aspects of perceived dyspnea, i.e., irrespective of the underlying generating mechanism. In contrast, only the descriptors of the super ordinate cluster work of breathing, in particular the effort cluster, seem to mirror the intensity (sensory) aspects of dyspnea. It is tentative to speculate that, therefore, the descriptors related to work of breathing provide more precise information on the underlying pathophysiology than descriptors related to air hunger. This might be further related to differences in the neural and cortical processing between work of breathing and air hunger (26). However, an alternative and rather realistic explanation to date is that we studied healthy participants who normally do not have elaborated experiences with feelings of bronchoconstriction or suffocation. This might have resulted in a specific use of descriptors of the clusters obstruction and suffocation not fully comparable to that of patients suffering from dyspnea. The missing correlations between intensity and unpleasantness of dyspnea and verbal descriptors during voluntary breath-holding might also relate to this circumstance. Since this is the first study relating intensity and unpleasantness of dyspnea to verbal descriptors of this sensation, future studies with an extended experimental protocol and the inclusion of different dyspneic patient samples are clearly required to extend the present findings.

In summary, the present study suggests that separable clusters of German language descriptors of dyspnea are reliably used by healthy volunteers. The obtained clusters effort, speed, obstruction and suffocation are widely comparable to previously described clusters in other languages, but are differently related to the intensity and unpleasantness of dyspnea.

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