Dynamic stability association with cost of transport is different in patients with COPD compared to healthy controls

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INTRODUCTION

- Chronic obstructive pulmonary disease (COPD) is a chronic lung disease that affects not only the lungs but also the neuromuscular system, leading to deficits in functional performance and increased fall risk [1,2].
- In this situation, increased muscle activity is needed to provide safe walking patterns, stability while walking.
- This increase in muscle activity leads to increased metabolic cost, i.e., using more oxygen to complete the task.

PURPOSE:

- the main objective of this study was to investigate the relationship between walking stability and metabolic cost in patients with COPD in comparison with age-matched controls.

METHODS

Group	N	Age (years)	Body mass (kg)	Height (m)
Healthy	23	59.95±6.60	73.72± 15.85	1.63± 0.07
COPD	17	64.3± 7.64	89.71± 31.70	1.67± 0.11

- Subjects (Tab. 1) were instructed to walk on a treadmill at three different speeds including preferred, fast (+20% preferred) and slow (-20% preferred) speeds, while motion capture data was recorded (Fig. 1).
- Margin of stability (MOS) mean and variability (i.e., standard deviation) at each heel strike was calculated for each of the walking trials [4](Fig. 2).
- Energy cost of transport (COT) was calculated by subtracting the energy consumption values at standing from walking conditions to achieve net metabolic cost for each condition [3].
- Pearson correlation was used to determine the association between MOS and COT.

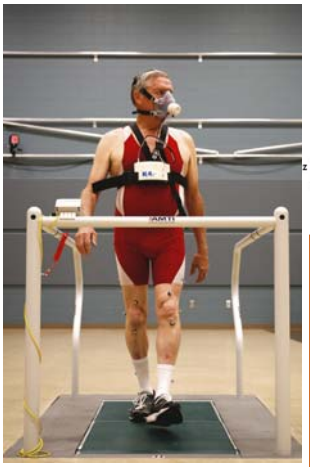

Figure 1. Patient with COPD walking on treadmill while reflective markers were placed on his body and outfitted with a portable metabolic measurement unit

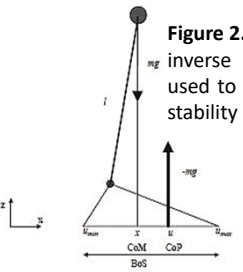

Figure 2. A schematic of the inverse pendulum model used to calculate margin of stability

Margin of stability was calculated based on inverted pendulum model adapted from Hof et al [4], using the position(x) and velocity (v) of a subject's center of mass and boundary of support (u_{max}) of each foot according to the following equation:

$$b = |u_{max} - (x + {}^{v}/_{\omega_0})|$$

where ω_0 is the Eigen frequency of inverted pendulum derived from following equation :

$$\omega_0 = \sqrt{{}^{g}/_{l}}$$

- Repeated measures ANOVA (2 groups x 3 speeds) was used to determine differences in groups and between speeds.

RESULTS

- MOS variability in AP direction was increased in patients with COPD compared to healthy older adults (Fig. 3).
- For both groups, increased mean MOS AP while walking faster was found in comparison with slow and preferred speed conditions (p=0.001). In addition, when walking at a slower speed, MOS variability in AP direction was increased in comparison with fast (p<0.0001) and preferred speed (p=0.004).
- Increased mean MOS ML was found for both groups while walking at preferred speed compared to fast speed (p=0.007).
- The mean MOS AP had an inverse association with COT in both groups for all speeds (Tab. 2). People with lower margins of stability (higher chance of losing balance), had higher COT while walking. However, the relationship was stronger in healthy subjects and weaker in patients with COPD.

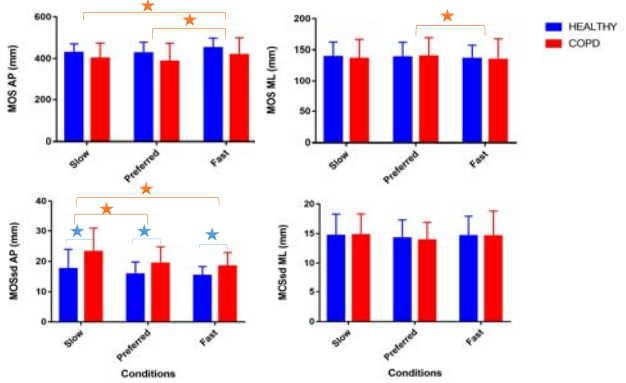

Figure 3. Comparison of AP and ML MOS across group during each walking speed condition. * represents between group/condition differences (p<0.05).

Table 2. R-values for Pearson correlation between MOS values and COT during preferred, slow and fast speeds. * Significant correlations (p<0.05), **** Significant correlations (p<0.0001)

CONDITION	GROUP	MOS AP mean/COT	MOS ML mean/COT	MOS sd AP/COT	MOS sd ML/COT
PREFERRED	HEALTHY	-0.77****	-0.09	0.26	-0.34
	COPD	-0.49	0.33	0.11	-0.14
SLOW	HEALTHY	-0.42*	-0.22	0.48	0.02
	COPD	-0.15	0.10	0.24	0.09
FAST	HEALTHY	-0.76****	-0.28	0.22	-0.30
	COPD	-0.50	0.33	0.22	0.046

DISCUSSION and CONCLUSIONS

- The weaker relationship between MOS and COT in patients with COPD, could be due to the changes in lung function and muscular system.
- Patients with COPD may decrease their speed to achieve a more stable walking pattern, which costs them more to move.
- Muscle fatigue in patients with COPD could be a contributing factor that leads to abnormal structure and function of muscle causing increased MOS variability in AP direction.

REFERENCES

[1] Crisan et al. Plos one 10, e0120573, 2015.
[2] Beauchamp et al. Respir Med, 103, 1885-189, 2009.
[3] Browning et al. J Appl Physiol,100, 390-398, 1985.
[4] Hof et al. J Biomech, 38, 1-8, 2005.