Heart Rate Recovery & Oxygen Recovery Kinetics in Individuals with Comorbid Insomnia and Obstructive Sleep Apnea Before and After Exercise alone or in combination with Cognitive Behavioural Therapy for Insomnia

Félix Michel Girard[2], Amanda Camalleri[1], Thien Thanh Dang-Vu[1,2,3], Jean-Philippe Gouin[1], Véronique Pepin[1,4]

[1]PERFORM Centre, Concordia University, Montréal, QC , Canada; [2]Department of Health, Kinesiology and Applied Physiology, Concordia University, Montréal, QC, Canada; [3]Centre de recherche, Institut Universitaire de Gériatrie de Montréal, Montréal, QC, Canada; [4]Centre de recherche, CIUSSS du Nord-de-l'Île-de-Montréal, Montréal, QC, Canada

Introduction

- Insomnia: problematic sleep initiation/maintenance and/or early morning awakenings causing daytime difficulties. Chronically, it increases cardiovascular and autonomic nervous system dysfunction risks
- Obstructive sleep apnea (OSA): intermittent anatomical closure of the upper airways, resulting in oxygen deprivation and increased arousal during sleep leading to cardiometabolic and nervous system damages
- Comorbid insomnia and sleep apnea (COMISA):
  - Affects 35-58% of people with OSA
  - Known to complicate diagnosis and treatment response
  - Associated to greater health risks in comparison to either condition alone
- Recovery phase following cardiopulmonary exercise test (CPET): allows for measurement of recovery kinetics, which assess cardiovascular and autonomic system integrity
- Heart rate recovery (HRR), oxygen recovery slopes (VO2/t) and time to half VO_{2max} recovery (T½): used to describe impaired recovery kinetics in insomnia or OSA alone

No studies have yet characterized recovery kinetics nor investigated the effect of potential interventions in people with COMISA

Objectives

1. **Describe recovery kinetics following CPET in people with COMISA**
2. **Investigate their response to either Exercise training alone (Ex) or combined with cognitive-behavioral therapy for insomnia (CBTi-Ex)**

Methods

Study Design & Interventions

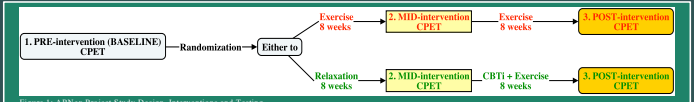

Figure 1: APNex Project Study Design, Interventions and Testing

Study Design

Secondary analysis of data from the pilot randomized controlled trial called the APNex Project

Exercise (Ex)

- 3 exercise training sessions (1 supervised) per week
- 40-minutes aerobic training at a moderate intensity (heart rate corresponding to ventilatory threshold obtained from most recent CPET)
- Resistance training (1 set of 12-15 repetitions for 6-8 different exercises)

Cognitive-Behavioural Therapy for insomnia combined with Exercise (CBTi-Ex)

- Relaxation consisted of at home psychoeducation and breathing exercise
- CBTi sessions incorporating four 60 minutes modules (i.e., sleep hygiene, cognitive restructuring) offered every other week in combination with Ex

Cardiopulmonary Exercise Test (CPET) & Recovery Kinetics

CPET

- Symptom limited Jones Protocol on a cycle ergometer
- Gas exchange parameters assessed breath-by-breath by open circuit spirometry
- Maximal exercise capacity parameters calculated during the last 30 seconds of test[1]
- Recovery protocol: active recovery consisting of 5 min of unloaded pedalling, during which data for recovery kinetics were assessed

Heart Rate Recovery (HRR)

From HR_{max}, HRR [bpm] was calculated for the first (HRR1), second (HRR2) and fifth minute (HRR5) as the difference between HRmax and the HR at minute 1, 2 and 5 following test termination, respectively

Oxygen Recovery Slopes (VO_2/t)

From VO_{2max}, VO_2/t slopes [L/min²] for the first (VO_2/t 1), second (VO_2/t 2) and fifth (VO_2/t 5) minutes of recovery were calculated by linear regression following test termination, respectively[2]

Time to Half VO_{2max} Recovery (T½)

Time to reduce oxygen consumption by half from peak consumption (T½) was calculated from the time it took to record the first breath with a VO_2 value of half or less of the established VO_{2max}

Statistical Analysis: Repeated measures ANOVA (Pre- to Mid- & Pre- to Post-)
Time as the within subject factor, interventions as the between subject factor
Significance level was set at $p < 0.05$, large effect size[3] at : partial eta squared (ηp^2) ≥ 0.140

Results

Baseline characteristics and cardiopulmonary response to peak exercise and recovery kinetics at baseline in COMISA

Table 1: Baseline demographics and characteristics of participants

Variables	Mean (SD)	Min	Max
Subjects [n]	17		
Males [n] / Females [n]	7 / 10		
CPAP Yes [n] / CPAP No [n]	10 / 7		
Age [years]	55 (13)	29	70
Height [cm]	166 (11)	142	188
Weight [kg]	90 (22)	67	142
BMI [kg/m²]	32.8 (9.5)	23.3	56.0

CPAP = Continuous Positive Airway Pressure; BMI= Body Mass Index

Table 2: Peak Response to CPET and Recovery Kinetics at baseline (n=17)

Variables	Mean (SD)	Min	Max
HR_{max} [BPM]	146 (23)	106	175
HR_{max} [% Predicted]	88 (12)	67	107
VO_{2max} [L/min]	1.87 (0.83)	0.98	4.18
VO_{2max} [ml/kg/min]	21.1 (7.9)	11.0	43.8
VO_{2max} [% Predicted]	69 (21)	34	108
Work [Watt]	163 (76)	83	356
RER	1.22 (0.10)	0.99	1.42
RPE (Borg Scale)	16 (2)	12	19
HRR1 [BPM]	20 (7)	9	35
HRR2 [BPM]	35 (8)	25	53
HRR5 [BPM]	49 (13)	21	70
VO_2/t 1 [L/min²]	0.731 (0.521)	0.102	2.370
VO_2/t 2 [L/min²]	0.590 (0.288)	0.159	1.447
VO_2/t 5 [L/min²]	0.222 (0.096)	0.097	0.504
T½ [sec]	97 (64)	51	329

HR_{max} = max heart rate, VO_{2max} = maximal oxygen consumption, RER = respiratory exchange ratio, RPE = rate of perceived exertion, HRR = heart rate recovery, VO_2/t = oxygen recovery slope, T½ = time to half oxygen recovery

Changes in recovery kinetics after Ex or Relaxation

Pre- to Mid-
Differences between interventions

No statistically significant main effects (of time or group) **or interaction of time by group**

Strong effect sizes for interaction of time by group for HRR5 (ηp^2 = 0.232) and VO_2/t 1(ηp^2 = 0.215)

Similar Pre- and Mid- CPETs in both groups for HRRs and T½

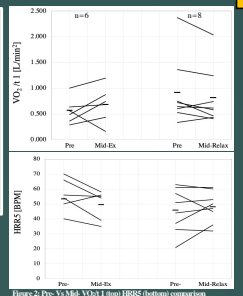

Figure 2: Pre- Vs Mid- VO_2/t 1 (top) HRR5 (bottom) comparison by groups and participants (individual lines)

Changes in recovery kinetics after Ex or CBTi-Ex

Pre- to Post
Changes across time

Significant effects of time VO^2/t 2 (p = 0.045) and VO^2/t 5 (p = 0.017)

Similarity between Ex & CBTi-Ex effects on recovery kinetics

No improvement in both groups for T½ and HRRs

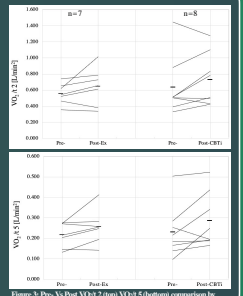

Figure 3: Pre- Vs Post VO_2/t 2 (top) VO_2/t 5 (bottom) comparison by groups and participants (individual lines).

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Conclusion

1) Baseline CPETs in people with COMISA were indicative of **poor recovery kinetics**
2) Our findings suggest that **exercise training** has the potential to improve oxygen recovery kinetics
3) Further studies with **standardized recovery protocols** should be done to characterize recovery kinetics in COMISA and to evaluate Ex or CBTi-Ex potential benefits more precisely

Selected References

1) ATS/ACCP (2003). Statement on Cardiopulmonary Exercise Testing. *American Journal of Respiratory and Critical Care Medicine*, *167*(2), 211–277. https://doi.org/10.1164/rccm.167.2.211

2) Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences. Routledge.

3) Nanas, S., Sakellariou, D., Kapsimalakou, S., Dimopoulos, S., Tassiou, A., Tasoulis, A., Anastasiou-Nana, M., Vagiakis, E., & Roussos, C. (2010). Heart Rate Recovery and Oxygen Kinetics After Exercise in Obstructive Sleep Apnea Syndrome. *Clinical Cardiology*, *33*(1), 46–51. https://doi.org/10.1002/clc.20707