Anxiety, CO2 tolerance, and breath practice in high school students: feasibility and observations from a 6-week slow breathing program

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Abstract

Purpose: One in 3 American adolescents meet the criteria for anxiety, and suicide is the second leading cause of death globally among 15-29 year-olds. Research supports connections between breathing manipulation and emotional states, and tolerances to endogenous carbon dioxide (CO_2) levels and anxiety. We observed students' short and long-term anxiety and CO_2 tolerance (CO2T) during a slow-breathing program at a rural Pennsylvania high school.

Methods: A 6-week slow-breathing program was administered to 26 10th-12th grade students in 2 health/physical education (HPE) classes. Three times/week, an HPE teacher led students through 5 minutes of 5-second inhales, 5-second breath holds, 10-second exhales, and 5-second breath holds. The State-Trait Anxiety Inventory Trait (STAI-Trait) Scale was administered at the beginning and end of the 6 weeks. The STAI-State Anxiety Scale short version and a timed-exhale CO2T measure were administered weekly before and after the breath practice. Two-sided paired t-tests were used to evaluate changes in STAI-Trait before-to-after the 6-week program, and STAI-State and CO2T before-to-after the breathing exercises.

Results: Of 26 students, 20 (73%) completed all 6 weekly state anxiety and CO2T measurements; 6 completed 5 of 6; and 1 completed 4 of 6. After 6 weeks, trait anxiety scores were significantly improved across all students (mean 44.2 pre, 41.2 post, p=0.0116). State anxiety improved (p<0.03) immediately following the breathing exercises in weeks 1, 4, 5, and 6, and CO2T improved (p<0.015) in weeks 1, 2, 4, 5, and 6. Qualitative feedback was mixed immediately after the program's end and was mostly positive weeks later at semester's end.

Conclusions: A 6-week high school program of thrice-weekly, 5-minute group slow breathing was feasible and was associated with short- and long-term adaptations to anxiety and endogenous CO_2. Prospective studies are warranted to confirm the potential benefits of simple, low-cost approaches such as these towards ending the stress-management crisis among today's youth.

Background

- Nearly one in 3 adolescents (31.9%) in the US meet the criteria for anxiety,[1] and suicide is the second leading cause of death globally among 15-29 year-olds.[2]
- The relationship between breathing and anxiety is well established, both in general and among adolescents.[3,4]
- Research also supports connections between emotional states and physiological responses during breathing, including to endogenous carbon dioxide (CO_2) levels.[5,6]

Objectives

- We designed a slow-breathing program for high school youth based on the hypothesis that regular practice of slow breathing would reduce psychological and physiological stress responses.
- The program was implemented in a Physical Education (PE) class at a rural Pennsylvania high school Nov-Dec 2019.
- Participation, short and long-term anxiety, and CO_2 tolerance (CO2T) were recorded.
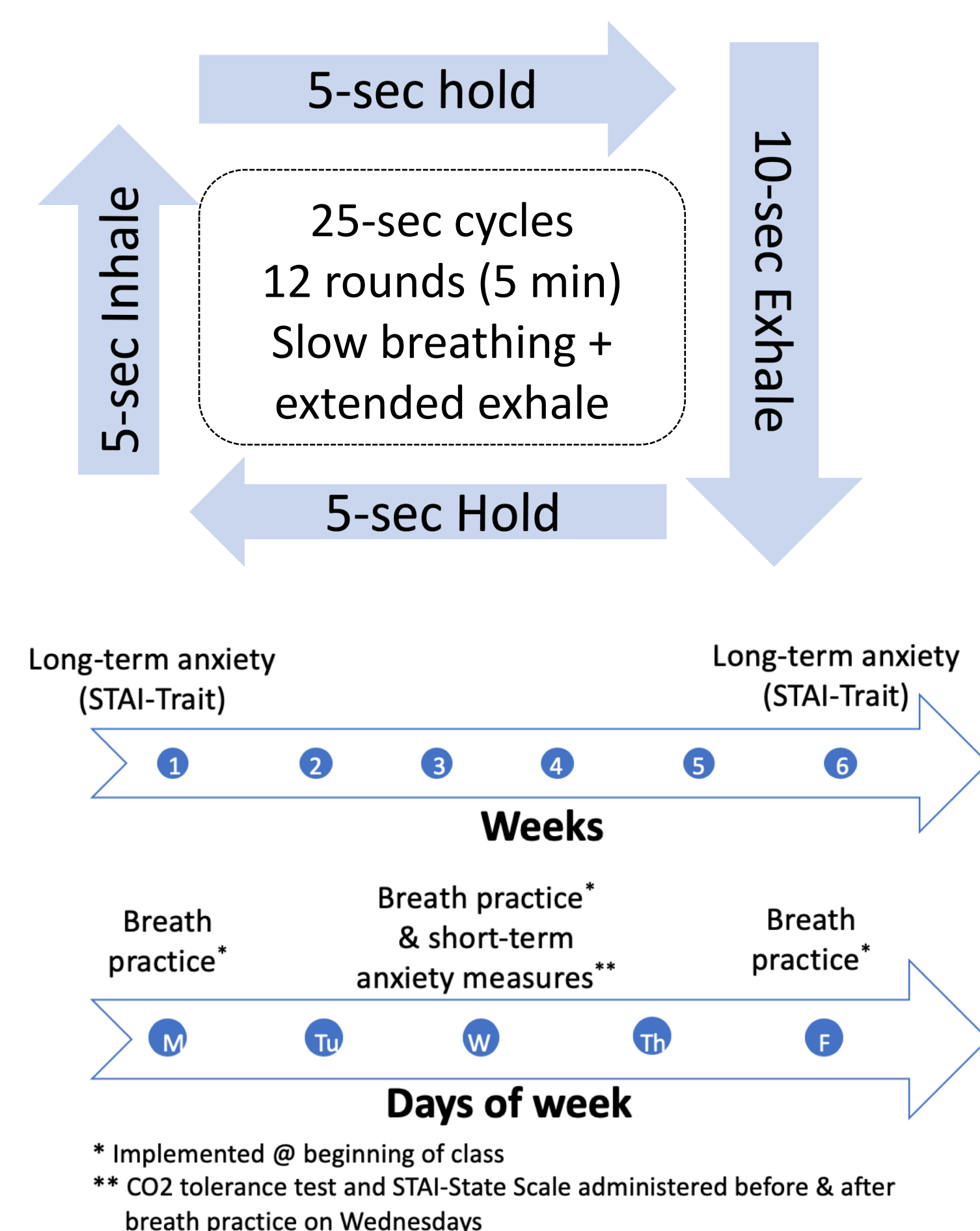
Methods

6-week slow-breathing program:

- Parents signed waivers for student participation
- PE teacher led class in slow breathing (2.4 breaths/minute) 3x/week

5-sec hold
5-sec Inhale
10-sec Exhale
5-sec Hold
25-sec cycles
12 rounds (5 min)
Slow breathing + extended exhale

Measures:

- Long-term ("trait") anxiety was measured before and after program with STAI-Trait[7]
- Short-term stress responses were measured 1x/week during the 6-week program using:
  - Psychometric: STAI-State short version[8]
  - Physiological: timed-exhale test of exogenous CO_2 tolerance (CO2T)

Long-term anxiety (STAI-Trait) — Weeks 1 2 3 4 5 6 — Long-term anxiety (STAI-Trait)

Breath practice* — Breath practice* & short-term anxiety measures** — Breath practice*

Days of week — M Tu W Th F

* Implemented @ beginning of class
** CO2 tolerance test and STAI-State Scale administered before & after breath practice on Wednesdays

Program evaluation

- "Feasible" was defined as ≥⅔ (66.6%) completion average of the breath practices.
- Two-sided paired t-tests were used to evaluate changes in:
  - STAI-Trait before-to-after the 6-week program
  - STAI-State and CO2T before-to-after breathing exercises
- Qualitative evaluations were completed by students at the 6-week program's end and at semester's-end

Results

Feasibility of slow breathing program

- All 26 (100%) students who started the program completed ≥2/3 of the breath sessions.
- 20 (73%) completed 100% of the weekly anxiety and CO2T measurements.

Stress responses to slow breathing program

- Long-term ("trait") anxiety significantly decreased (p=0.012) after the program (Table 1).
- Immediately following the slow-breathing practice (Tables 2-3):
  - Short-term ("state") anxiety significantly decreased (p<0.05) in 4 of the 6 weeks;
  - Physiological stress response, measured by tolerance to endogenous CO_2, significantly improved in 5 of the 6 weeks.

Trait Anxiety Before-After 6-week Slow-Breathing Program

STAI-State Pre-Post Breath Practice: Overall 6-week Observations

CO2TT Scores Pre-Post Breath Practice: Overall 6-week Observations

Table 1. STAI-Trait Anxiety Pre-Post 6-week Slow-Breathing Program: Paired T-Test

	Pre	Post
Mean	44.23	41.23
t Stat	2.725	
P(T<=t) two-tail	0.01158*	

* Statistically significant at p<0.05.
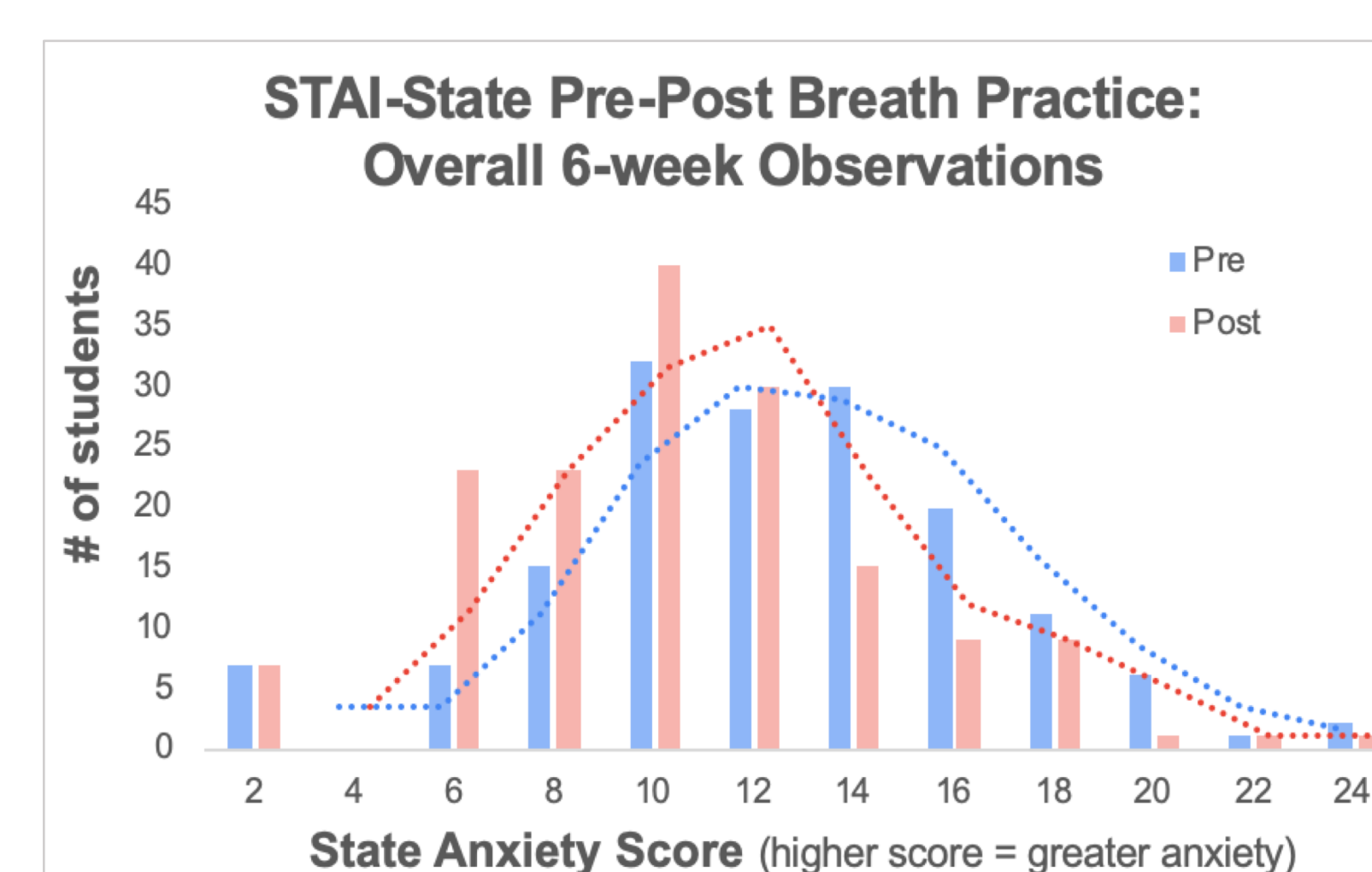
Table 2. STAI-State Anxiety Pre-Post Slow-Breathing Practice: Weekly Paired T-Tests

	Means		t-statistic	p(T<=t) 2-tailed
	Pre	Post		
Week 1	12.7	10.4	3.359	0.0025*
Week 2	11.8	10.8	1.920	0.0663
Week 3	9.8	8.7	1.580	0.1258
Week 4	13.2	10.7	3.156	0.0041*
Week 5	11.0	9.6	2.301	0.0296*
Week 6	12.5	9.9	3.378	0.0024*

* Statistically significant at p<0.05.
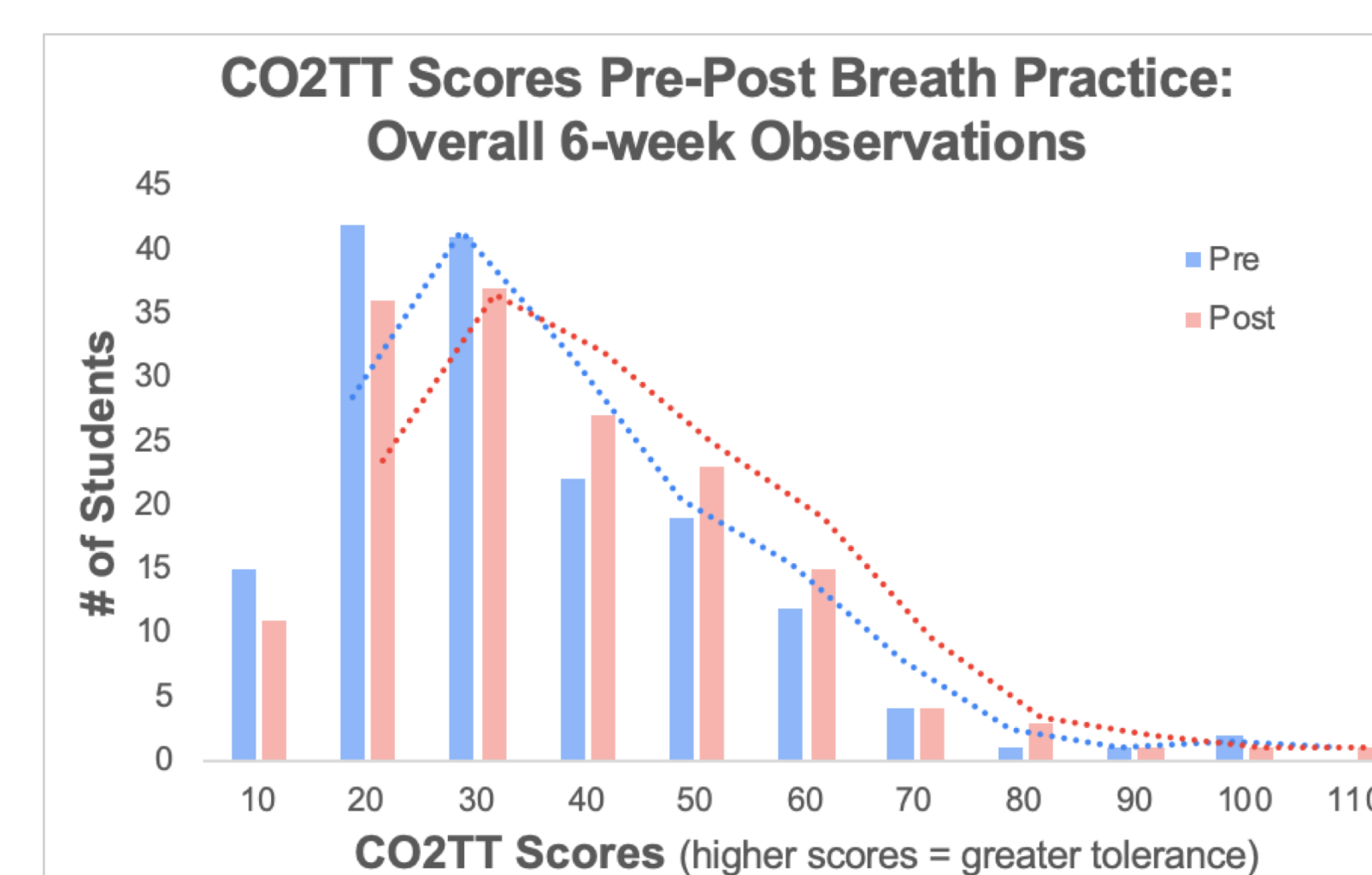
Table 3. CO2TT Pre-Post Slow-Breathing Practice: Weekly Paired T-Tests

	Means		t-statistic	p(T<=t) 2-tailed
	Pre	Post		
Week 1	25.7	29.2	-3.606	0.0014*
Week 2	29.5	32.5	-3.182	0.0039*
Week 3	25.2	25.3	-0.027	0.9783
Week 4	32.3	34.8	-2.692	0.0125*
Week 5	29.5	31.8	-3.690	0.0010*
Week 6	35.0	38.5	-3.153	0.0042*

* Statistically significant at p<0.05.

Conclusions

- This 6-week high school program of a 3x/week, 5-minute, teacher-led group slow breathing was feasible and was associated with:
  - Short- and long-term adaptations to psychological stress;
  - Short-term adaptations to physiological stress responses.
- Prospective studies are warranted to further explore benefits of simple, low-cost approaches such as that used in this program towards ending the stress-management crisis among today's youth.

References

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8. Marteau TM, Bekker H. The development of a six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (ST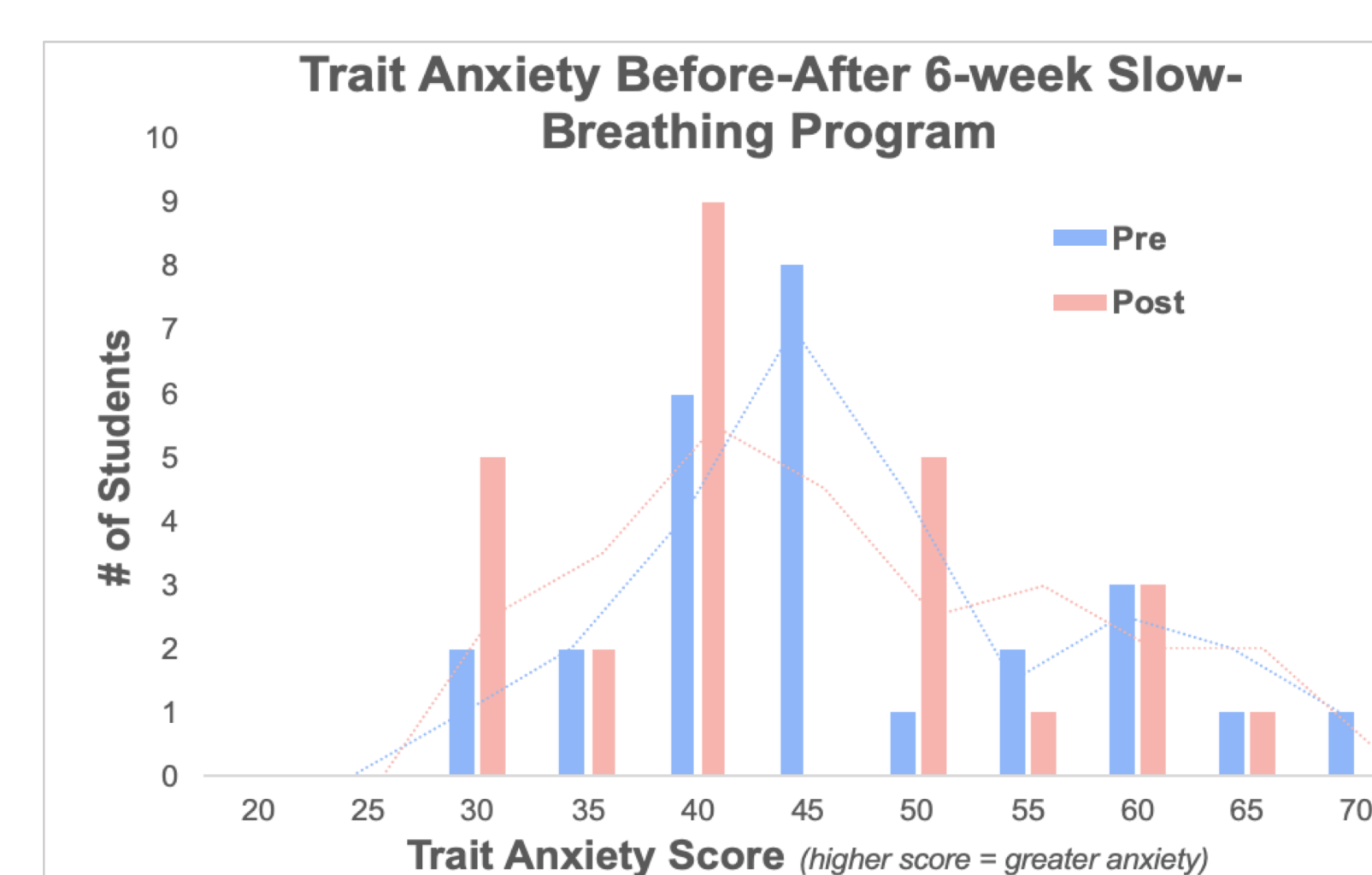AI). Br J Clin Psychol. 1992 Sep;31 (Pt 3):301-6.