

## 太极拳运动呼吸健康效应的监测与评价

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**摘要: 目的:** 呼吸作为基本的生命活动, 不仅在维持气体交换中发挥作用, 更直接参与自主神经系统的调节。研究表明, 缓慢、深长的呼吸训练能够有效增强迷走神经活性, 提高副交感神经张力, 进而改善心率变异性、稳定血压, 并促进身体的恢复能力。呼吸方式的优化亦与运动表现、免疫功能及心血管健康密切相关, 成为近年来生理调控领域的重要研究方向。太极拳通过独特的“呼吸-动作”协同模式, 在改善呼吸效率与自主神经调节方面具有潜在优势, 但其具体作用机制仍需系统性的实证研究加以验证。研究将探讨太极拳练习对副交感神经活性的增强作用, 评估其在提升以心率变异性 (HRV) 为代表的自主神经系统功能中的作用机制; 分析太极拳通过腹式呼吸训练, 改善呼吸功能, 包括潮气量、肺活量与最大通气量等关键参数的效果; 探索太极拳练习对自主神经系统功能、呼吸功能与行为层面 (压力感知与焦虑水平) 之间协同变化的促进作用, 揭示其构建“神经—呼吸—行为”整合调节机制的潜力。**方法:** 本研究选取 18-22 岁健康受试者, 分为具有太极拳训练经验的实验组 (n=8) 与无规律运动习惯的对照组 (n=8)。采用 HPS-102 人体生理实验系统测量心率变异性 (HRV) 与呼吸功能 (潮气量、肺活量、最大通气量等) 指标, 并辅以行为层面调查 (压力感知量表、焦虑自评问卷) 进行补充分析。数据分析方法包括 Mann-Whitney U 检验与 Spearman 相关性分析。**结果:** (1) 自主神经功能方面: 太极拳组在 pNN50 与 SD1 等副交感神经活性指标上显著高于对照组 ( $p=0.05$ ), RMSSD 亦呈现中等效应量 ( $r=0.50$ )。 (2) 呼吸功能方面: 太极拳组潮气量 (VT) 与最大自主通气量 (MVV) 均显著提升 ( $p<0.05$ ), 且效应量较大 ( $r=0.66$  与  $0.56$ )。 (3) 行为层面方面: 太极拳组焦虑评分较对照组下降 31%, 虽无统计学差异, 但与 HRV 指标间存在趋势性相关, 提示可能存在“神经—呼吸—行为”调节路径; 此外, SD1 与 pNN50, MVV 与 VT 指标之间呈现显著相关性, 进一步支持太极拳可能通过多系统整合机制提升机体调节功能。**结论:** (1) 太极拳能够增强副交感神经活性, 提高以心率变异性 (HRV) 为代表的自主神经系统短时调节功能。 (2) 太极拳有助于改善基础呼吸模式, 提升潮气量、肺活量及最大通气能力, 优化呼吸功能。 (3) 太极拳可能通过神经—呼吸—行为的整合调节机制, 促进个体生理功能与行为状态的协同改善。

**关键词:** 太极拳; 呼吸功能; 心率变异性; 自主神经系统

## **Monitoring and Evaluation of the Respiratory Health Effects of Tai Chi Exercise**

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**Abstract: Background:** Respiration is a fundamental physiological process essential for gas exchange and autonomic nervous system (ANS) regulation. Researches have shown that slow, deep breathing training can effectively enhance vagal nerve activity, increase parasympathetic tone, thereby improving heart rate variability, stabilizing blood pressure, and promoting the body's recovery ability. The optimization of breathing patterns is also closely related to sports performance, immune function, and cardiovascular health, making it an important research direction in the field of physiological regulation in recent years. Tai Chi, with its unique "breathing - movement" coordination mode, has potential advantages in improving respiratory efficiency and autonomic nerve regulation, but its specific mechanism of action still needs systematic empirical research to verify. This study will explore the enhancing effect of Tai Chi practice on parasympathetic nerve activity, evaluate its mechanism in improving autonomic nervous system function represented by heart rate variability (HRV); analyze the effect of Tai Chi on improving respiratory function, including key parameters such as tidal volume, vital capacity, and maximum ventilation volume through abdominal breathing training; explore the promoting effect of Tai Chi practice on the coordinated changes among autonomic nervous system function, respiratory function, and behavioral aspects (pressure perception and anxiety level), and reveal its potential in constructing an integrated regulatory mechanism of "nerve - respiration - behavior". **Methods:** Sixteen healthy participants (aged 18–22 years) were stratified into Tai Chi-experienced (n=8) and non-exercising control (n=8) groups. Using the HPS-102 physiological testing system, we measured heart rate variability (HRV) and respiratory parameters (tidal volume [VT], vital capacity). Behavioral assessments included the Perceived Stress Scale (PSS) and Generalized Anxiety Disorder-7 (GAD-7). Mann-Whitney U tests and Spearman correlation analyses were employed. **Results:** (1) ANS Function: The Tai Chi group exhibited significantly enhanced vagal tone, evidenced by elevated pNN50, with RMSSD showing a medium effect size. (2) Respiratory Function: Significant improvements in VT and maximum voluntary ventilation were observed with large effect sizes.

(3) Behavioral Outcomes: Anxiety scores decreased by 31% in the Tai Chi group versus controls (non-significant trend). Correlation trends between HRV indices and behavioral measures suggested a potential *neuro-respiratory-behavioral* regulatory pathway. Significant intra-system correlations (SD1↔pNN50; MVV↔VT) supported Tai Chi's role in multisystem integration. **Conclusion:** (1) Tai Chi enhances vagally-mediated HRV indices, indicating improved autonomic regulation; (2) optimizes respiratory patterns through increased VT and MVV; and (3) may promote physiological-behavioral coordination via an integrated *neuro-respiratory-behavioral* mechanism.

**Keywords:** Tai Chi; respiratory function; heart rate variability (HRV); autonomic nervous system; mind-body exercise

