

太极拳干预对老年人自主神经系统影响的循证研究

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摘要: 目的: 自主神经系统包括交感神经和副交感神经。它是支配和调节人体内脏功能的中枢和周围神经成分。在控制生理功能方面有重要作用: 控制、调节各种器官、血管、平滑肌和腺体的活动, 参与葡萄糖、脂肪、水和电解质代谢的内分泌调节, 以及体温、睡眠和血压。交感-副交感神经系统在大脑皮层和下丘脑的控制下, 既能对抗又能协调器官的生理活动。目前研究表明, 老年人的功能健康状况会随着年龄的增长下降, 神经系统的功能、认知能力下降, 甚至出现情绪障碍等精神疾病。主要表现为心脏自主神经系统活性下降, 心率时域和频域指标下降, 血压、脉搏、呼吸和内分泌失调。主要的机制可能是心交感神经和心迷走神经功能的障碍。已有研究证实, 太极拳作为一种低强度有氧运动, 可以改善老年人的神经系统功能和交感-副交感神经活动的调节能力; 长期进行多种形式的太极锻炼, 可以有效控制血压, 改善局部血流, 平衡心交感神经和心迷走神经的冲动, 促进心血管神经的自主调节。更新和修复神经细胞; 促进新陈代谢; 提高自主神经的活性, 恢复不平衡的交感神经和副交感神经系统之间相互抑制和制约的复杂动态平衡; 改良老年人心率变异性; 维持老年人自主神经年轻态。由于自主神经系统的功能结构复杂, 对其功能评价有不同的研究方法。心率变异性 (HRV) 包含了心血管调节的重要信息, 其相关指数被认为是确定自主神经活动的定量指标。分析心率变异性指数可以间接定量评估交感神经和副交感神经的张力和平衡。能全面反映运动后机体安静状态、运动状态和心动周期的变化。因此, 本研究评估了太极拳干预前后人体心率变异性的主要指标: 正常 RR 间期标准差 (SDNN)、相邻 RR 间期差值均方根 (RMSSD)、低频功率 (LF)、高频功率 (HF), (LF/HF) 等。分析神经系统的活动。通过各项指标的比较分析, 反映自主神经的活动情况。本文将回顾和分析太极拳对老年人自主神经系统的影响。**方法:** 通过检索电子文献数据库 (中国期刊全文数据库 (CNKI)、VIP 数据库、万方数据库、PubMed), 检索到的文献类型包括期刊论文和学位论文。检索方法包括高级检索和自由组合检索。纳入标准: (1) 随机对照试验 (RCT) (2) 研究对象: 健康老年人 (3) 干预措施: 太极拳运动干预, 研究必须涉及明确的运动周期和单次运动时间 (4) 观察指标: 主要观察指标为时域 (SDNN、RMSSD) 和频域 (LF、HF 和 LF/HF)。收集 73 篇关于太极拳干预对老年

人自主神经系统影响的循证文献进行分析。Cochrane16 评估系统用于评估研究人员独立评估所有纳入文献的质量，并从所选文献中提取相关数据，包括纳入文献的相关内容（作者、发文年份），研究对象的情况（实验组和对照组的数量、国家）、研究设计、实验人口总数和对照人口总数。使用了统计软件 stata16 对 11 篇文献进行荟萃分析和循证研究。计算各文献和预期指标的效用量和总体效用，统计运动干预疗效，估计疗效值的准确性。

结果：采用文献筛选法（Jadad 量表）对文献进行筛选。最后，11 篇文章被纳入荟萃分析，包括 9 篇具有统计学意义的中等质量研究文献。使用统计软件 stata16 对 11 篇文献进行荟萃分析和循证研究。

(1)太极拳运动对 HRV 时域指标的影响：SDNN 和 RMSSD 的研究分为 6 组，共 332 名受试者（太极拳运动组 172 名，对照组 172 名）。与纳入研究的受试者相比，异质性检验 $I^2=94\%$ ，表明研究之间没有异质性。因此，通过荟萃分析，太极拳组和对照组之间存在显著差异， $SMD=0.444$ ， $94.9\%CI$ ， $P=0.001$ 。结果表明，太极拳能有效提高老年人的 SDNN 和 RMSSD 水平；

(2) 太极拳运动对 HRV 频域指标的影响：频域指标包括 LF、HF 和 LF/HF。共有 7 组（太极拳习练组 237 人，对照组 237 人）被纳入研究。LF、HF 和 LF/HF 异质性测试结果分别为 $I^2=94.5\%$ 、 $I^2=82.2\%$ 和 $I^2=79.6\%$ ，表明各研究之间没有异质性。因此，采用随机实验模型进行数据元分析。结果表明，LF、HF 和 LF/HF 值增加。说明太极拳练习可以提高老年人的频域指标水平。其可能机制是运动刺激心脏交感神经，提高其脉冲频率，呈现心脏交感神经优势现象。

结论：随着年龄的增长，老年人的自主神经功能和活动性降低。交感神经和副交感神经之间的平衡存在问题；心脏交感神经和心脏迷走神经活动障碍。太极拳运动显著提高老年人 HRV 线性时域指标（SDNN、RMSSD）；对老年男性 HRV 频域指标（LF、HF 和 LF/HF）也有显著影响。SDNN 为心动周期间期的标准差，RMSSD 为连续心动周期间期均方差的平方根，SDNN 和 RMSSD 的值决定心脏收缩间期的长度，即心动周期的舒张期长度。LF/HF 代表心脏交感神经-心脏迷走神经的平衡状态。LF/HF 越接近 1，心脏交感神经-心脏迷走神经的平衡状态越稳定。根据荟萃分析：

(1) 太极拳练习后，老年人的 HRV 时域指标 SDNN 和 RMSSD 显著增加，表明迷走神经张力显著增加，说明太极拳练习能有效提高老年人的心率，有效延长老年人的 SDNN，降低心肌缺血的可能性。改善老年人心率变异性，改善自主神经功能和活动性；

(2) 太极拳练习后，心率变异性频域指标 LF 和 LF/HF 降低，HF 和 TP 指标升高，TP 差异显著，HF 差异非常显著，说明太极拳练习可以提高人体有氧运动能力。练习太极拳时间较长的人的心功能比不锻炼的老年人显示出更多的活力。迷走神经张力明显增加，交感神经稳定性增强，交感神经、副交感神经张力及交感-副交感神经平衡增强；

(3) 同时, 长期太极拳锻炼可以显著降低老年男性的 TP 值, TP 是 HRV 的总功率, 代表 HF、LF 和 VLF 之和, 也是 HRV 的典型频域指标。其机理是经过长期太极拳体育锻炼, 身体有氧运动能力相对提高, 迷走神经张力显著增加, 交感神经的稳定性增强。本研究还存在以下不足和局限性: 由于文献检索的局限性, 我们仅在国内这些文献图书馆进行文献检索, 检索语言仅包括中英文, 大多数研究没有制定详细的太极拳练习监控方案, 不排除不可控和不可测量因素对实验结果的干扰, 也难以对实验进行亚组分析。可比性存在局限性, 本研究需要更好的设计方案和更大的数据样本量、更严格的干预时间, 有待进一步研究和验证。

关键词: 太极拳; 老年人; 自主神经系统; 循证研究

Evidence based study on the effect of Taijiquan intervention on autonomic nervous system in the elderly

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Abstract: Objective: Autonomic nervous system includes sympathetic and parasympathetic nerves. It is the central and peripheral nerve components that dominate and regulate the visceral function of the body. It plays an important role in controlling the physiological function: It controls and regulates the activities and secretion of various organs, blood vessels, smooth muscle and glands, and participates in endocrine regulation of glucose, fat, water and electrolyte metabolism, as well as body temperature, sleep and blood pressure. Under the control of cerebral cortex and hypothalamus, sympathetic parasympathetic system can both antagonize and coordinate the physiological activities of organs. At present, research shows that the functional health status of the elderly will gradually decline with age, the function and activity of nervous system decline, cognitive decline, even emotional disorders and other mental diseases. mainly manifested in the decrease of cardiac autonomic nervous system activity, the decrease of time-domain and frequency-domain indexes of heart rate, and the imbalance of blood pressure, pulse, respiration and endocrine. The main mechanism may be the dysfunction of cardiac sympathetic nerve and cardiac vagus nerve. Previous studies have confirmed that Taijiquan, as a low-intensity aerobic exercise, can improve the function of the main nervous system and the regulation ability of sympathetic parasympathetic nerve activity in the elderly; Long term Tai Chi exercise in

various forms can effectively control blood pressure, improve local blood flow, balance the impulse of cardiac sympathetic nerve and cardiac vagus nerve, and promote the autonomous regulation of cardiovascular nerve. Renew and repair aging nerve cells; Stimulate metabolism; Enhance cardiovascular health; Improve the activity of autonomic nerve and restore the complex dynamic balance of mutual inhibition and restriction between the unbalanced sympathetic nerve and parasympathetic nervous system; Improve heart rate variability in the elderly; Maintain the state of autonomic nerve rejuvenation in the elderly. Due to the complex functional structure of autonomic nervous system, there are different research methods for its functional evaluation. Heart rate variability (HRV) contains important information about cardiovascular regulation, and its correlation index is recognized as a quantitative index to determine autonomic nerve activity. Analyzing heart rate variability index can indirectly quantitatively evaluate sympathetic and parasympathetic tension and balance. It can completely reflect the changes of body quiet state, exercise state and cardiac cycle after exercise. Therefore, this study evaluates the main indexes of human heart rate variability before and after Taijiquan intervention: standard deviation of normal RR intervals (SDNN), root-mean-square of difference-value of adjacent RR interval (RMSSD), low-frequency power (LF), high-frequency power (HF), low-frequency power/ high-frequency power (LF/HF) and so on. To analyze the activity of the nervous system. The activity of autonomic nerve was reflected through the comparison and analysis of various indexes. This paper will review and analyze the effects of Taijiquan on the autonomic nervous system of the elderly by meta-analysis. **Methods:** Through the retrieval of electronic literature databases (China journal full text database (CNKI), VIP database, Wan fang database, PubMed and web of Science), the retrieved literature types include journal papers and degree papers. The retrieval methods adopted include advanced retrieval and free combination retrieval. Inclusion criteria: (1) randomized controlled trial (RCT). (2) Subjects: healthy elderly people (3) Intervention measures: Taiji exercise intervention, the study must involve a clear motion cycle and single motion time. (4) OUTCOME MEASURES: The main outcome measures were time domain (SDNN, RMSSD) and frequency domain (LF, HF and LF/HF). A total of 73 evidence-based literatures on the impact of Taijiquan intervention on the autonomic nervous system of the elderly were collected to analysis. Cochrane16 evaluation system was used to evaluate the researchers independently evaluated the quality and offset risk of all the included literatures and extracted relevant data which were

extracted from the selected literature, including the basic contents of the included literature (author, year of publication), the basic situation of the research objects (number of experimental group and control group, country), research design, total number of experimental population and total number of control population. The literatures were screened in turn according to the screening literature flow chart. Statistical software stata16 was used to conduct meta-analysis and evidence-based research on 11 literatures. The utility quantity and overall utility of each literature and expected indicators were calculated, and the exercise intervention efficacy was counted and the accuracy of effect value was estimated. **Results:** The literature was screened by literature filtering (Jadad scale). Finally, 11 articles were included in the meta-analysis, including 9 medium-quality research literatures with statistical significance. Statistical software stata16 was used to conduct meta-analysis and evidence-based research on 11 literatures. (1) Influence of Taijiquan Exercise on HRV time domain index: the research of SDNN and RMSSD included 6 groups, a total of 332 subjects (172 in Taijiquan exercise group and 172 in control group). Compared with the subjects included in the study, the heterogeneity test $I^2=94\%$, which showed that there was no heterogeneity between the studies. Therefore, there was a significant difference between the Tai Chi group and the control group by meta-analysis, $SMD=0.444$, 94.9% CI, $P=0.001$. It shows that Taijiquan can effectively improve the SDNN and RMSSD levels of the elderly; (2) Influence of Taijiquan Exercise on HRV frequency domain indicators: frequency domain indicators include LF, HF and LF/HF. A total of 7 groups (237 in Taijiquan practice group and 237 in control group) were included in the study. The results of LF, HF and LF/HF heterogeneity test were $I^2 = 94.5\%$, $I^2=82.2\%$ and $I^2=79.6\%$ respectively, which showed that there was no heterogeneity among various studies. Therefore, the random experimental model was used for data meta-analysis. The results showed that the values of LF, HF and LF/HF increased significantly. It shows that Taijiquan practice can improve the frequency domain index level of the elderly. The possible mechanism is that exercise stimulates the cardiac sympathetic nerve, enhances its impulse frequency, and presents the phenomenon of superiority of cardiac sympathetic nerve. **Conclusion:** With the increase of age, the autonomic nerve function and activity of the elderly decrease. There is a problem in the balance between sympathetic and parasympathetic nerves; Cardiac sympathetic nerve and cardiac vagus nerve activity disorder. Taijiquan exercise significantly promoted the HRV linear time domain indexes (SDNN, RMSSD) of the elderly; It also had a significant effect

on HRV frequency domain indexes (LF, HF and LF/HF) in elderly men. SDNN refers to the standard deviation of cardiac cycle interval, RMSSD refers to the square root of the mean square difference of continuous cardiac cycle interval, and the values of SDNN and RMSSD determine the length of cardiac systolic interval, that is, the length of diastolic period of cardiac cycle. LF/HF represents the balance state of cardiac sympathetic nerve cardiac vagal nerve. The closer LF/HF is to 1, the more stable the balance state of cardiac sympathetic nerve cardiac vagal nerve is. According to meta-analysis: (1) After Taijiquan practice, the HRV time domain indexes SDNN and RMSSD of the elderly increased significantly, which showed that the vagus nerve tension increased significantly, indicating that Taijiquan practice can effectively improve the heart rate of the elderly, effectively prolong the SDNN of the elderly and reduce the possibility of cardiac muscle ischemia. It can improve the heart rate variability of the elderly and improve the function and activity of autonomic nerve; (2) After Taijiquan practice, HRV frequency domain indexes LF and LF/HF decreased, HF and TP indexes increased, TP difference was significant, and HF difference was very significant, indicating that Taijiquan practice can improve human aerobic exercise ability. The heart function of people who practice Taijiquan for a longer time showed more vitality than the elderly who do not exercise. The tension of vagus nerve increased significantly, the stability of sympathetic nerve increased, the tension of sympathetic nerve and parasympathetic nerve and the balance of sympathetic parasympathetic nerve were enhanced; (3) Meanwhile, Long term Taijiquan exercise can significantly reduce the TP value of elderly men, TP is the total power of HRV, representing the sum of HF (sympathetic active high frequency component), LF (sympathetic active low frequency component) and VLF (very low frequency component), It is also a typical frequency domain index of HRV. Its mechanism is that after long-term Taijiquan physical exercise, the body's aerobic exercise ability is relatively improved, the tension of vagus nerve is significantly increased, and the stability of sympathetic nerve is increased. There are still the following deficiencies and limitations in this study: Due to the limitation of retrieval of literature, we only conducted literature retrieval in these literature libraries at home and abroad, and the retrieval language only include Chinese and English, thus the relevant studies in other languages are not included in this paper, most studies have not formulated a detailed Taijiquan practice monitoring scheme, which not rule out the interference of uncontrollable and unmeasurable factors on the experimental results, and it is difficult to conduct

subgroup analysis of the experiment. There are limitations in comparability, this study needs better design scheme and larger data sample size. More stringent intervention time to further study and verify.

Key words: Taijiquan, aged, Autonomic nervous system, Evidence based research