分论坛 1:太极拳科学化的相关研究

不同运动周期太极（八法五步）运动过程中脑功能连接的特征研究

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摘要：研究背景：运动心理学领域的研究发现运动能够重塑脑结构，优化重组脑功能。太极拳是具有鲜明中华传统文化特征的健身养生运动，是身心运动的代表，正受到越来越多研究者的关注。前人的研究发现，太极拳能够增强左侧内侧额上回 fALFF、SFGdor.R 与左侧角回功能连接的、提升脑功能网络局部信息传输效率，且效果优于健步走。然而，以往的大多数研究都集中在太极拳干预前后两个时间点大脑功能或结构的变化，难以精准捕捉太极拳运动中大脑功能活动的实时变化。随着便携式功能性近红外光谱（fNIRS）的发展，探索身体运动过程中大脑血流动力学的变化成为可能。研究目的：本研究以大学生为对象，探索不同运动周期（4 周、8 周）太极拳运动状态中脑功能活动的实时变化特征及其随干预周期变化的规律，阐明太极拳提升个体执行功能的内在脑功能机制。**研究方法：**以 90 名大学生为研究对象，太极组拳进行 8 周太极（八法五步）运动干预，健步走组进行 8 周健步走干预。采用 fNIRS 技术在干预 4 周、干预 8 周时分别检测太极（八法五步）、健步走运动过程中脑血流动力学变化，采用小波相干分析探究运动过程中脑功能连接强度的变化及差异。**结果：**干预 4 周时，太极拳组与运动对照组存在差异的功能连接有 21 条，均为太极拳的功能连接强度高于运动对照组。具体表现为：太极拳运动状态中右侧内侧额上回-右侧中央前回（$p=0.039<0.05$）、右侧内侧额上回-右侧中央后回（$p=0.028<0.05$）、右侧内侧额上回-左侧颞上回（$p=0.009<0.01$）、左侧背外侧额上回-右侧缘上回（$p<0.001$）、左侧背外侧额上回-右侧颞上回（$p=0.021<0.05$）、左侧背外侧额上回-左侧缘上回（$p<0.001$）、左侧内侧额上回-右侧中央前回（$p=0.002<0.01$）、左侧内侧额上回-右侧缘上回（$p=0.001$）、左侧内侧额上回-右侧颞上回（$p<0.001$）、左侧内侧额上回-左侧缘上回（$p=0.025<0.05$）、左侧内侧额上回-左侧中央后回（$p=0.012<0.05$）、左侧内侧额上回-左侧颞上回（$p=0.015<0.05$）、右侧背外侧额上回-右侧中央前回（$p=0.001$）、右侧背外侧额上回-右侧中央后回（$p=0.022<0.05$）、右侧背外侧额上回-右侧颞上回（$p=0.001$）、右侧背外侧额上回-左侧颞

上回（p=0.025＜0.05）、右侧中央前回-右侧缘上回（p＜0.001）、右侧中央前回-右侧颞上回（p=0.004＜0.01）、右侧中央前回-左侧颞上回（p=0.010）、右侧中央后回-右侧颞上回（p=＜0.001）、右侧颞上回-左侧缘上回（p=0.006＜0.01）的功能连接均高于运动对照组。（2）干预 8 周时，太极拳组与运动对照组存在差异的功能连接有 30 条，均为太极拳的功能连接强度高于运动对照组。结果发现，太极拳运动状态中右侧内侧额上回-右侧中央前回（p=0.030＜0.05）、右侧内侧额上回-右侧中央后回（p=0.003＜0.01）、右侧内侧额上回-右侧颞上回（p＜0.001）、右侧内侧额上回-左侧颞上回（p＜0.001）、左侧背外侧额上回-右侧中央前回（p＜0.001）、左侧背外侧额上回-右侧缘上回（p＜0.001）、左侧背外侧额上回-右侧中央后回（p=0.001）、左侧背外侧额上回-右侧颞上回（p＜0.001）、左侧背外侧额上回-左侧中央前回（p=0.001）、左侧背外侧额上回-左侧缘上回（p＜0.001）、左侧背外侧额上回-左侧中央后回（p=0.005＜0.01）、左侧背外侧额上回-左侧颞上回（p=0.001）、左侧内侧额上回-右侧中央前回（p＜0.001）、左侧内侧额上回-右侧缘上回（p＜0.001）、左侧内侧额上回-右侧中央后回（p＜0.001）、左侧内侧额上回-右侧颞上回（p＜0.001）、左侧内侧额上回-左侧缘上回（p＜0.001）、左侧内侧额上回-左侧中央后回（p＜0.001）、左侧内侧额上回-左侧颞上回（p＜0.001）、右侧背外侧额上回-右侧中央前回（p＜0.001）、右侧背外侧额上回-右侧缘上回（p=0.002＜0.01）、右侧背外侧额上回-右侧中央后回（p＜0.001）、右侧背外侧额上回-右侧颞上回（p＜0.001）、右侧背外侧额上回-左侧颞上回（p＜0.001）、右侧中央前回-右侧缘上回（p＜0.001）、右侧中央前回-右侧中央后回（p＜0.001）、右侧中央前回-右侧颞上回（p＜0.001）、右侧中央前回-左侧颞上回（p＜0.001）、右侧中央后回-右侧颞上回（p＜0.001）、右侧颞上回-左侧缘上回（p＜0.001）的功能连接均高于运动对照组。**研究结论：**（1）与健步走运动相比，太极（八法五步）过程中两侧前额叶（内侧额上回、背外侧额上回）与两侧额叶（中央前回）、顶叶（缘上回、中央后回）、颞叶（颞上回）的功能连接更强，且随着干预周期的增加，太极（八法五步）运动过程中脑功能连接增强脑区更多。

关键词：太极（八法五步）；近红外；大学生

Characteristics of brain function connection during different dxercise cycles of BaFa WuBu of Tai Chi

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Abstract：Background: Previous studies in the field of sports psychology have demonstrated that physical exercise has the potential to induce structural and functional changes in the brain and enhance cognitive performance. Tai Chi, a traditional Chinese exercise rooted in both physical and mental components, has garnered growing interest among researchers due to its unique cultural characteristics and potential health benefits. Previous studies have found that BaFa WuBu of Tai Chi can enhance fALFF in the left medial superior frontal gyrus, the functional connection between the right dorsolateral superior frontal gyrus and the left angular gyrus, and improve the efficiency of local information transmission in the brain functional network, with better results than brisk walking. However, most previous studies have focused on changes in brain function or structure at two time points before and after Tai Chi intervention, making it difficult to accurately capture real-time changes in brain functional activities during Tai Chi exercise. With the development of portable functional near-infrared spectroscopy (fNIRS), it is possible to explore changes in cerebral hemodynamics during physical activity. **Purpose:** This study focuses on college students and explores the real-time changes in brain functional activities during different exercise cycles (4 weeks, 8 weeks) of Tai Chi exercise, as well as the patterns of changes with intervention cycles. It elucidates the internal brain functional mechanism of Tai Chi improving individual executive function. **Method:** 90 college students were selected as the research subjects. The Tai Chi group received 8 weeks of BaFa WuBu of Tai Chi exercise intervention, the exercise control group received 8 weeks of brisk walking intervention. fNIRS technology was used to detect changes in cerebral hemodynamics during BaFa WuBu of Tai Chi and brisk walking exercise at 4 and 8 weeks of intervention. Wavelet coherence analysis was used to explore changes and differences in brain functional connectivity strength during exercise. **Results:** （1） After 4 weeks of intervention, a total of 21 functional connections were found to exhibit significant differences between the Tai Chi Chuan group and the exercise control group. Notably, all of these connections demonstrated a higher strength in the Tai Chi group compared to the exercise control group. Specifically, the functional connections involving the SFGmed.R-PreCG.R （p=0.039 < 0.05）、SFGmed.R-PoCG.R （p=0.028 < 0.05）、SFGmed.R-STG.L （p=0.009 < 0.01）、SFGdor.L-SMG.R（p < 0.001）、SFGdor.L-STG.R（p=0.021 < 0.05）、SFGdor.L-SMG.L （p < 0.001）、SFGmed.L-PreCG.R （p=0.002 < 0.01）、SFGmed.L-SMG.R （p=0.001）、SFGmed.L-STG.R （p < 0.001）、SFGmed.L-SMG.L （p=0.025 < 0.05）、SFGmed.L-PoCG.L

（p=0.012 < 0.05）、SFGmed.L-STG.L（p=0.015 < 0.05）、SFGdor.R-PreCG.R（p=0.001）、SFGdor.R-PoCG.R（p=0.022 < 0.05）、SFGdor.R-STG.R（p=0.001）、SFGdor.R-STG.L（p=0.025 < 0.05）、PreCG.R-SMG.R（p < 0.001）、PreCG.R-STG.R（p=0.004 < 0.01）、PreCG.R-STG.L（p=0.010）、PoCG.R-STG.R（p= < 0.001）、STG.R-SMG.L（p=0.006 < 0.01）, were found to be significantly stronger in the Tai Chi exercise group as compared to the exercise control group.

（2） After 8 weeks of intervention, a total of 30 functional connections were found to exhibit significant differences between the Tai Chi Chuan group and the exercise control group. Notably, all of these connections demonstrated a higher strength in the Tai Chi group compared to the exercise control group. Specifically, the functional connections involving the SFGmed.R-PreCG.R（p=0.030 < 0.05）、SFGmed.R-PoCG.R（p=0.003 < 0.01）、SFGmed.R-STG.R（p < 0.001）、SFGmed.R-STG.L（p < 0.001）、SFGdor.L-PreCG.R（p < 0.001）、SFGdor.L-SMG.R（p < 0.001）、SFGdor.L-PoCG.R（p=0.001）、SFGdor.L-STG.R（p < 0.001）、SFGdor.L-PreCG.L（p=0.001）、SFGdor.L-SMG.L（p < 0.001）、SFGdor.L-PoCG.L（p=0.005 < 0.01）、SFGdor.L-STG.L（p=0.001）、SFGmed.L-PreCG.R（p < 0.001）、SFGmed.L-SMG.R（p < 0.001）、SFGmed.L-PoCG.R（p < 0.001）、SFGmed.L-STG.R（p < 0.001）、SFGmed.L-SMG.L（p < 0.001）、SFGmed.L-PoCG.L（p < 0.001）、SFGmed.L-STG.L（p <0.001）、SFGdor.R-PreCG.R（p < 0.001）、SFGdor.R-SMG.R（p=0.002 < 0.01）、SFGdor.R-PoCG.R（p < 0.001）、SFGdor.R-STG.R（p < 0.001）、SFGdor.R-STG.L（p < 0.001）、PreCG.R-SMG.R（p < 0.001）、PreCG.R-PoCG.R（p < 0.001）、PreCG.R-STG.R（p < 0.001）、PreCG.R-STG.L（p < 0.001）、PoCG.R-STG.R（p < 0.001）、STG.R-SMG.L（p < 0.001）, were found to be significantly stronger in the Tai Chi exercise group as compared to the exercise control group.**Conclusion:** (1) Compared with brisk walking exercise, the functional connections between the two prefrontal lobes (medial superior frontal gyrus, dorsolateral superior frontal gyrus) and the two frontal lobes (central anterior gyrus), parietal lobe (marginal superior gyrus, central posterior gyrus), and temporal lobe (superior temporal gyrus) during Tai Chi (eight methods and five steps) exercise are stronger, and with the increase of intervention cycles, the brain functional connections are enhanced in more brain regions during Tai Chi (eight methods and five steps) exercise.

Key words：Tai Chi Chuan, fNIRS, college student