

人参醇提取物对老年果蝇睡眠的改善作用及其机制

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[摘要] **目的:** 探讨人参醇提取物(GEE)通过维持氧化还原平衡改善老年果蝇模型睡眠的作用, 并阐明其相关作用机制。**方法:** 随机选取32只7 d龄雄性黑腹果蝇作为年轻组, 另选64只35 d龄雄性黑腹果蝇随机分为老年组和GEE组, 每组32只, 给药7 d后利用DAM2果蝇行为学分析系统分析各组果蝇总睡眠时长、日间睡眠时长、夜间睡眠时长、关灯后4 h内睡眠时长(ZT0-4睡眠时长)、深睡眠时长、睡眠发生次数和睡眠片段化等睡眠参数以及总自主活动次数、日间自主活动次数和夜间自主活动量等活动参数。果蝇分组同上, 每组100只, 利用基于双向荧光差异凝胶电泳(2D-DIGE)和基质辅助激光解析电离飞行时间质谱(MALDI-TOF-MS)的蛋白质组学方法对果蝇脑组织中差异表达蛋白进行筛选、鉴定及功能分析。果蝇分组同上, 每组100只, 利用试剂盒法检测各组果蝇脑组织中超氧化物歧化酶(SOD)、过氧化氢酶(CAT)和谷胱甘肽过氧化物酶(GSH-Px)活性及脂质过氧化产物(MDA)水平。**结果:** 与年轻组比较, 老年组果蝇总睡眠时长、日间睡眠时长和夜间睡眠时长缩短($P<0.05$ 或 $P<0.01$); 与老年组比较, GEE组果蝇总睡眠时长、日间睡眠时长和夜间睡眠时长延长($P<0.01$)。与年轻组比较, 老年组果蝇ZT0-4睡眠时长、深睡眠时长和睡眠片段化缩短($P<0.05$ 或 $P<0.01$), 睡眠节律振幅缩短; 与老年组比较, GEE组果蝇ZT0-4睡眠时长、深睡眠时长和睡眠片段化延长($P<0.01$), 睡眠节律振幅提高。与年轻组比较, 老年组果蝇日间自主活动量和总自主活动量无明显变化, 差异无统计学意义($P>0.05$), 夜间自主活动量增加($P<0.05$); 与老年组比较, GEE组果蝇日间自主活动量、夜间自主活动量和总自主活动量均减少($P<0.05$ 或 $P<0.01$)。2D-DIGE电泳图谱中共筛选出47个差异表达蛋白, 与年轻组比较, 老年组果蝇脑组织中蛋白表达下调; 与老年组比较, GEE组果蝇脑组织中蛋白表达上调, 差异表达蛋白主要包括谷胱甘肽S转移酶、过氧化物氧化蛋白1和二氢硫辛酸脱氢酶等调控氧化还原平衡相关的蛋白。与年轻组比较, 老年组果蝇脑组织中SOD、CAT和GSH-Px活性降低($P<0.05$ 或 $P<0.01$), MDA水平升高($P<0.01$); 与老年组比较, GEE组果蝇脑组织中SOD、CAT和GSH-Px活性升高($P<0.05$ 或 $P<0.01$), MDA水平降低($P<0.05$)。**结论:** GEE对老年果蝇睡眠具有改善作用, 其机制可能与提高抗氧化酶活性、抑制MDA积累和维持氧化还原平衡有关。

[关键词] 人参; 老年; 睡眠; 氧化还原平衡; 黑腹果蝇; 蛋白质组

[中图分类号] R285.5 **[文献标志码]** A

[收稿日期] 2024-09-05 **[录用日期]** 2024-10-28

[基金项目] 国家自然科学基金区域创新发展联合基金项目(U20A20402); 吉林省科技厅科技发展计划项目(YDZJ202301ZYT5463); 吉林省中医药管理局中医药科技项目(2024044); 吉林省教育厅科学技术研究项目(JJKH20230972KJ)

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Improvement effect of ginseng alcohol extract on sleep of aged drosophila and its mechanism

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ABSTRACT Objective: To investigate the impact of ginseng alcohol extract (GEE) on improving sleep quality in the aged *Drosophila* model by regulating the redox balance, and to elucidate its associated mechanism. **Methods:** Thirty-two male *Drosophila melanogaster* (7-days-old) were randomly selected as young group, while 64 male *Drosophila melanogaster* flies (35-days-old) were randomly assigned to aged model group ($n=32$) and GEE group ($n=32$). The sleep parameters, including total sleep duration, daytime sleep duration, night sleep duration, 0–4 h of sleep duration after lights off (ZT0-4 sleep duration), deep sleep duration, sleep episodetimes, sleep fragmentation, and the activity parameters such as the total number of locomotor activity daytime locomotor activity amount and nighttime locomotor activity amount were analyzed using the DAM2 *Drosophila* behavioral analysis system 7 d after administration. The grouping of the *drosophila* was as above, and there were 100 *drosophila* in each group. The differentially expressed proteins in *drosophila* brain tissue were screened, identified, and functionally analyzed using two-dimensional fluorescence difference gel electrophoresis (2D-DIGE) and matrix-assisted laser desorption/ionization time of flight mass spectrometry (MALDI-TOF/TOF-MS) proteomic methods. The grouping of the *drosophila* was as above, and there were 100 *drosophila* in each group. The activities of superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px) and the levels of lipid peroxidation product (MDA) in brain tissue of the *drosophila* were determined using assay kits. **Results:** Compared with young group, the total sleep duration daytime sleep duration and night sleep duration of the *drosophila* in aged group were decreased ($P<0.05$ or $P<0.01$); and the sleep rhythm amplitude was shortened. Compared with aged group, the total sleep duration and daytime and nighttime sleep durations of the *drosophila* in GEE group were lengthened ($P<0.01$). Compared with young group, the ZT0-4 sleep duration deep sleep duration and sleep fragment of the *drosophila* in aged group were decreased ($P<0.05$ or $P<0.01$), and the sleep rhythm amplitude was shortened. Compared with young group, the ZT0-4 sleep duration, deep sleep duration, and single sleep fragment of the *drosophila* in GEE group were significantly prolonged ($P<0.01$), and the sleep amplitude was increased. Compared with young group, there was no significant difference in diurnal spontaneous activity or total spontaneous activity of the *drosophila* in aged group ($P>0.05$), while the nocturnal spontaneous activity was significantly increased ($P<0.05$). Compared with aged group, the diurnal spontaneous activity, nocturnal spontaneous activity, and total spontaneous activity of the *drosophila* in GEE group were significantly decreased ($P<0.05$ or $P<0.01$). A total of 47 differentially expressed proteins were selected in the 2D-DIGE electrophoretic mapping. Compared with young group, the expressions of 47 differentially expressed protein sites in aged group were down-regulated mainly including glutathione S-transferase, peroxiredoxin 1 and dihydrolipoic dehydrogenase, which were related to redox balance. Compared with young group, the

activities of SOD, CAT and GSH-Px in brain tissue of the drosophila in aged group were decreased ($P < 0.05$ or $P < 0.01$), and the level of MDA was increased ($P < 0.01$); compared with aged group, the activities of SOD, CAT and GSH-Px in brain tissue of the drosophila in GEE group were increased ($P < 0.05$ or $P < 0.01$), and the MDA level was decreased ($P < 0.05$). **Conclusion:** GEE has improvement effect on the sleep quality of aged drosophila, and its possible mechanism may be related to upregulating the activities of antioxidant enzymes, inhibiting the accumulation of lipid peroxidation products, and maintaining redox balance.

KEYWORDS Ginseng; Aging; Sleep; Redox balance; *Drosophila melanogaster*; Proteome

睡眠障碍是衰老进程中常见现象之一,不仅影响个体生活质量,还可引发神经退行性疾病以及心脑血管、代谢和免疫系统等疾病^[1-4]。目前对于失眠的治疗方法主要包括药物治疗、心理疗法和非药物治疗等,然而上述方法都存在一定的局限性和不良反应,如药物治疗可能会导致药物依赖性、耐受性和戒断反应;心理疗法需要时间长、费用高且治疗效果因人而异;非药物治疗(音乐放松和按摩等)效果不稳定^[5-6]。中药因其具有多靶点、安全性高等优势,在缓解和治疗睡眠障碍方面备受关注^[7]。神农本草经记载:人参具有“安精神、定魂魄”的功效,且常以人参泡酒的服用方式改善睡眠障碍。近期研究^[8]显示:人参可改善氯苯丙氨酸诱导的大鼠失眠;临床试验研究^[9]表明:人参可改善慢性疲劳综合征患者睡眠状况。然而,目前对于人参改善老年人群相关睡眠障碍功效的物质组分挖掘及作用机制解析的相关研究鲜有报道。果蝇在睡眠行为与人类存在很多共有标准型特征,且与人类的同源基因相似度较高,现已成为研究睡眠的经典模式动物。本研究以黑腹果蝇为模型结合行为学分析系统,参考“人参泡酒”的入药方式,评价人参醇提取物(ginseng ethanol extract, GEE)改善老年相关睡眠障碍的功效,并通过蛋白质组学技术发掘其作用相关通路,初步阐明其功效机制,为GEE的临床应用提供实验依据。

1 材料与方法

1.1 药物、实验动物、主要试剂和仪器 GEE由长春天力健康食品有限公司提供。黑腹果蝇由东北师范大学生命科学学院提供。本研究实验操作遵守实验动物伦理保护法,并经过长春中医药大学实验伦理委员会批准(伦理批准号:2023096)。谷胱甘肽过氧化物酶(glutathione peroxidase, GSH-Px)、超氧化物歧化酶(superoxide dismutase, SOD)和过氧化氢酶(catalase, CAT)活性检测试剂盒及

脂质过氧化产物(malonydiadehyde, MDA)水平检测试剂盒购自南京建成生物工程研究所,BCA蛋白浓度测定试剂盒购自上海碧云天生物技术有限公司。果蝇行为学分析系统(型号:DAM2,美国Trikinetics公司),低温高速离心机(型号:5430R,德国Eppendorf公司),酶标仪(型号:Multiskan GO,美国Thermo公司),纯水仪(型号:Milli-Q,美国Merck公司),CO₂麻醉装置为实验室自制。

1.2 果蝇饲养、分组和给药 果蝇饲养明暗条件为12 h:12 h光照/黑暗周期,上午8:00时开灯,晚上20:00时关灯。温度26℃,相对湿度55%。基础培养基配制方法:40 g玉米粉与160 mL蒸馏水混匀成A溶液;30 g蔗糖、3 g琼脂和300 mL蒸馏水混匀加热煮沸至琼脂融化,将A溶液匀速缓慢倒入,并不断搅拌防止结块,继续煮沸后静置冷却至70℃,加入3 g酵母粉、3 mL丙酸,继续搅拌后分装至培养瓶中。含药培养基为基础培养基中加入1%质量体积比(W/V)的GEE。见图1。选择7 d龄雌性处女蝇为年轻组,35 d龄雌性处女蝇为老年组^[10],饲养于含GEE培养基的35 d龄雌性处女蝇为GEE处理的老年果蝇组(GEE组),每组32只。

1.3 果蝇睡眠监测和数据采集 利用DAM2行为学监测系统连续监测果蝇的活动和睡眠模式^[11]。果蝇给予基础培养基或加药培养基饲养7 d,于第8天经CO₂麻醉后移入行为学监测管中,一端用黑帽密封,另一端用棉球封堵,每管容纳一只果蝇。经12 h适应后将监测管插入果蝇活动监测系统DAM板。每板有32个单独的室,方便同时跟踪32只果蝇。随后将监测板与计算机连接。

DAM2系统的数据采集软件每隔1 min自动记录果蝇活动次数。以果蝇静止时间 ≥ 5 min为处于睡眠状态。利用EXCEL软件对数据进行处理。分别计算果蝇总睡眠时长、日间睡眠时长、夜间睡眠时长、关灯后4 h内睡眠时长(ZT0-4睡眠时长)、

24 h内睡眠发生次数、睡眠片段化(总睡眠时长/24 h内睡眠发生次数)以及深睡眠时长(≥ 15 min的睡眠时长总和),并利用EXCEL软件绘制睡眠节律图^[12]。

1.4 果蝇自主活动量采集和计算 以DAM2系统采集的数据为基础,每次计数即为该时间段果蝇的活动次数。将数据包导入EXCEL软件分别计算各组果蝇日间自主活动量、夜间自主活动量和单次活动时长,总自主活动量=日间自主活动量+夜间自主活动量。

1.5 双向荧光差异凝胶电泳(two-dimensional fluorescence difference gel electrophoresis,2D-DIGE)检测各组果蝇脑组织中差异表达蛋白 果蝇分组同上,每组果蝇($n=100$)置于冻存管中经液氮速冻后剧烈震荡,经自制锡纸筛收集果蝇头部于EP管中。低温磁珠震荡离心后取上清液,BCA法检测蛋白浓度后进行各组样品标记(Cy3和Cy5)及混合内标(Cy2),标记后的样品进行第一向等电聚焦电泳、平衡及第二向十二烷基硫酸钠聚丙烯酰胺凝胶电泳(sodium dodecyl sulfate polyacrylamide gel electrophoresis, SDS-PAGE)。所得凝胶经扫描成像(Cy2: 480/530 nm, Cy3: 520/590 nm, Cy5: 620/680 nm)。

1.6 各组果蝇脑组织中差异表达蛋白点的筛选及鉴定 利用DeCyder软件(英国Amersham Biosciences公司)软件进行图像分析及差异表达蛋白点筛选,差异表达蛋白点满足条件:丰度变化为1.3倍增加或减少和 P 值 ≤ 0.05 。经基质辅助激光解吸飞行时间质谱(matrix-assisted laser desorption/ionization time of flight mass spectrometry, MALDI-TOF-MS)法对差异表达蛋白点进行质谱鉴定,鉴定数据库为美国国家生物技术信息中心(National Center for Biotechnology Information, NCBI)全库。

1.7 采用试剂盒法检测各组果蝇脑组织中SOD、CAT和GSH-Px活性及MDA水平 果蝇分组同上,各组果蝇冷冻处死后取头部($n=100$),用生理盐水冰浴匀浆。匀浆离心后测定蛋白质含量。利用试剂盒法检测果蝇脑组织中CAT、SOD和GSH-Px活性及MDA水平,操作参照试剂盒说明书。

1.8 统计学分析 采用GraphPad Prism 7.0统计软件进行统计学分析。各组果蝇睡眠参数和活动参数,脑组织中CAT、SOD和GSH-Px活性及MDA水平均以 $\bar{x} \pm s$ 表示,多组间样本均数比较采用单因素方差分析,组间样本均数两两比较采用SNK- q 检验。以 $P < 0.05$ 为差异有统计学意义。

2 结 果

2.1 各组果蝇的睡眠时长 与年轻组比较,老年组果蝇日间睡眠时长、夜间睡眠时长和总睡眠时长缩短($P < 0.05$ 或 $P < 0.01$);与老年组比较,GEE组果蝇日间睡眠时长、夜间睡眠时长和总睡眠时长延长($P < 0.01$)。见表1。

表1 各组果蝇日间睡眠时长、夜间睡眠时长和总睡眠时长
Tab.1 Daytime sleep duration, nighttime sleep duration, and total sleep duration of drosophila in various groups
($n=32, \bar{x} \pm s, t/\text{min}$)

Group	Daytime sleep duration	Nighttime sleep duration	Total sleep duration
Young	267.66 $\pm$ 170.11	487.34 $\pm$ 155.82	755.00 $\pm$ 217.28
Aged	162.81 $\pm$ 133.84*	385.94 $\pm$ 169.35*	548.75 $\pm$ 203.37**
GEE	367.50 $\pm$ 125.19 Δ	568.13 $\pm$ 88.59 Δ	935.63 $\pm$ 176.53 Δ

* $P < 0.05$, ** $P < 0.01$ vs young group; $\Delta P < 0.01$ vs aged group.

2.2 各组果蝇的ZT0-4睡眠时长和深睡眠时长 与年轻组比较,老年组果蝇ZT0-4睡眠时长和深睡眠时长缩短($P < 0.05$);与老年组比较,GEE

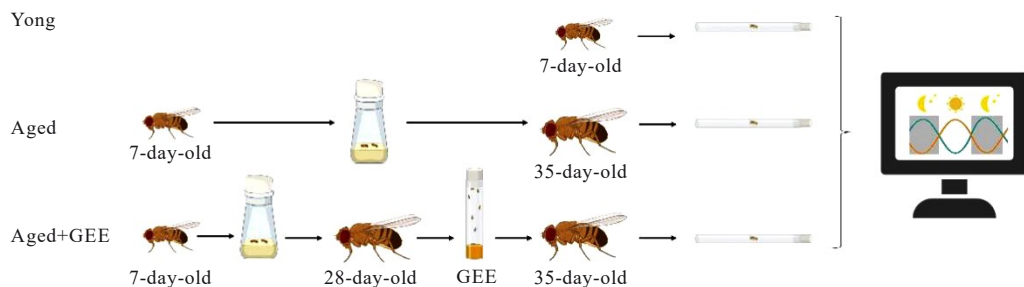


图1 果蝇分组和实验流程

Fig.1 Group and experimental process of Drosophila

组果蝇 ZT0-4 睡眠时长和深睡眠时长均延长 ($P<0.01$)。见表 2。

表 2 各组果蝇 ZT0-4 睡眠时长和深睡眠时长
Tab. 2 ZT0-4 sleep duration and deep sleep duration of drosophila in various groups ($n=32, \bar{x} \pm s, t/\text{min}$)

Group	ZT0-4 sleep time	Deep sleep time
Young	164.38±45.20	267.66±170.11
Aged	129.38±64.34*	162.81±133.84*
GEE	174.84±40.48 [△]	367.50±125.19 [△]

* $P<0.05$ vs young group; [△] $P<0.01$ vs aged group.

2.3 各组果蝇的睡眠发生次数、睡眠片段化和睡眠节律 与年轻组比较,老年组果蝇睡眠发生次数增加 ($P<0.01$),睡眠片段化缩短 ($P<0.01$);与老年组比较,GEE 组果蝇睡眠发生次数减少 ($P<0.01$),睡眠片段化延长 ($P<0.01$)。见表 3。各组果蝇睡眠周期的节律相位并未发生变化,但与年轻组比较,老年组果蝇睡眠节律振幅缩短;与老年组比较,GEE 组果蝇睡眠节律振幅提高。见图 2。

2.4 各组果蝇自主活动量和单次活动时长 与年

表 3 各组果蝇睡眠发生次数和睡眠片段化
Tab. 3 Sleep episode times and sleep fragmentation of drosophila in various groups ($n=32, \bar{x} \pm s$)

Group	Sleep episode times (time·24 h ⁻¹)	Sleep fragmentation (t/min)
Young	28.41±8.34	30.87±13.82
Aged	27.41±10.20*	17.26±8.59*
GEE	25.47±8.99 [△]	39.52±18.64 [△]

* $P<0.01$ vs young group; [△] $P<0.01$ vs aged group.

表 4 各组果蝇日间自主活动量、夜间自主活动量、总自主活动次数和单次活动时长
Tab. 4 Amounts of daytime locomotor activities and night locomotor activities and total numbers of locomotor activities and single activity duration of drosophila in various groups ($n=32, \bar{x} \pm s$)

Group	Daytime locomotor activity	Nighttime locomotor activity	Total number of locomotor activity	Single activity duration (t/min)
Young	518.25±300.74	320.66±266.87	838.91±512.36	38.15±30.75
Aged	696.75±354.32	416.97±252.08*	1 113.72±570.12	38.30±19.56
GEE	488.50±346.46 [△]	204.50±145.92 ^{△△}	693.00±436.15 ^{△△}	31.60±21.07

* $P<0.05$ vs young group; [△] $P<0.05$, ^{△△} $P<0.01$ vs aged group.

2.6 各组果蝇脑组织中 SOD、CAT 和 GSH-Px 活性及 MDA 水平 与年轻组比较,老年组果蝇脑组织中 SOD、CAT 和 GSH-Px 活性降低 ($P<0.05$ 或 $P<0.01$),MDA 水平升高 ($P<0.01$);与老年组

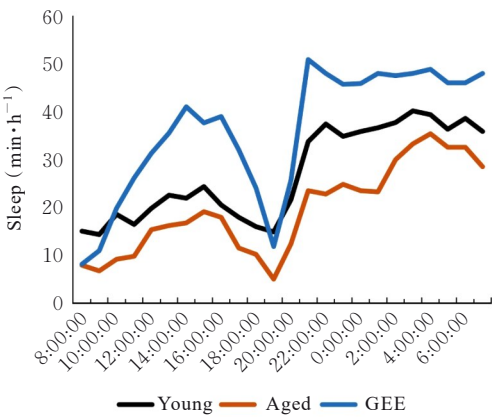


图 2 各组果蝇睡眠节律

Fig. 2 Sleep rhythm of Drosophila in various groups

轻组比较,老年组果蝇日间自主活动量和总自主活动量无明显变化,差异无统计学意义 ($P>0.05$),夜间自主活动量增加 ($P<0.05$);与老年组比较,GEE 组果蝇日间自主活动量、夜间自主活动量和总自主活动量均减少 ($P<0.05$ 或 $P<0.01$)。3 组果蝇单次活动时长比较差异无统计学意义 ($P>0.05$)。见表 4。

2.5 各组果蝇脑组织中差异表达蛋白图谱及功能分类 将各组果蝇脑组织中蛋白进行三色荧光 (Cy2、Cy3 和 Cy5) 标记并进行双向电泳分离,基于各蛋白点荧光强度筛选差异表达蛋白,共挖取 47 个差异表达蛋白点,与年轻组比较,老年组果蝇脑组织中蛋白表达下调;与老年组比较,GEE 组果蝇脑组织中蛋白表达上调。见图 3。

差异表达蛋白功能主要与氧化还原平衡有关,如谷胱甘肽 S 转移酶、过氧化物氧还蛋白 1、二氢硫辛酸脱氢酶和甘油-3-磷酸脱氢酶等。见图 4。

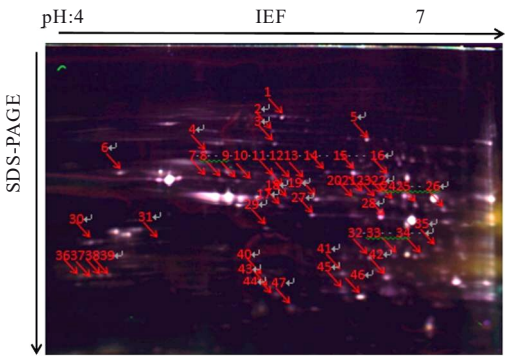


图3 各组果蝇脑组织中差异表达蛋白点

Fig.3 Different expression protein points in brain tissue of drosophila in various groups

3 讨论

本研究利用黑腹果蝇评价了GEE对老年果蝇睡眠障碍的改善作用。通过对睡眠时长的分析，发现GEE可延长老年导致的睡眠时长减少。在睡眠质量方面，本研究选择睡眠潜伏期、深睡眠时长、睡眠片段化和睡眠节律振幅进行系统评价。通过计算ZT0-4时长评价睡眠潜伏期的变化，睡眠潜伏期对整个睡眠过程起着至关重要的作用，其有助于更快地进入深度睡眠状态，提高整体睡眠质量。果

蝇≥15 min的睡眠时长被定义为深睡眠时长。深睡眠是人体在夜间休息过程中最为重要的阶段之一，有助于身体修复和能量恢复；睡眠片段化是指睡眠中出现频繁醒来和睡眠断裂的现象，导致整夜的睡眠无法连续进行，进而影响人们白天的精神状态和注意力集中能力，甚至可能引发认知功能下降等问题。睡眠节律图是通过记录个体或群体在一定时间内的睡眠状态而绘制出的图表。振幅大小代表睡眠周期中深度睡眠和浅度睡眠的变化情况，振幅越大则表明深度睡眠阶段更为稳定且持续时间较长，通常意味着较好的睡眠质量。因此，通过观察和分析睡眠节律图的振幅大小可用来评估个体或群体的睡眠规律和质量。研究^[13]表明：老年果蝇表现为睡眠潜伏期延长、深睡眠时长缩短、睡眠片段化加重和睡眠节律振幅降低等现象，与本研究结果一致；而GEE预处理可明显改善上述指标，表明GEE在质量和数量上均具有改善老年相关睡眠障碍的功效。良好的睡眠质量对于保持日间活动能力至关重要。同时，日间活动也会影响到夜间睡眠质量^[14]。因此，本研究在分析果蝇睡眠参数的同时，也对其自主活动情况进行了表征，证明GEE无神经麻痹的安全性问题。

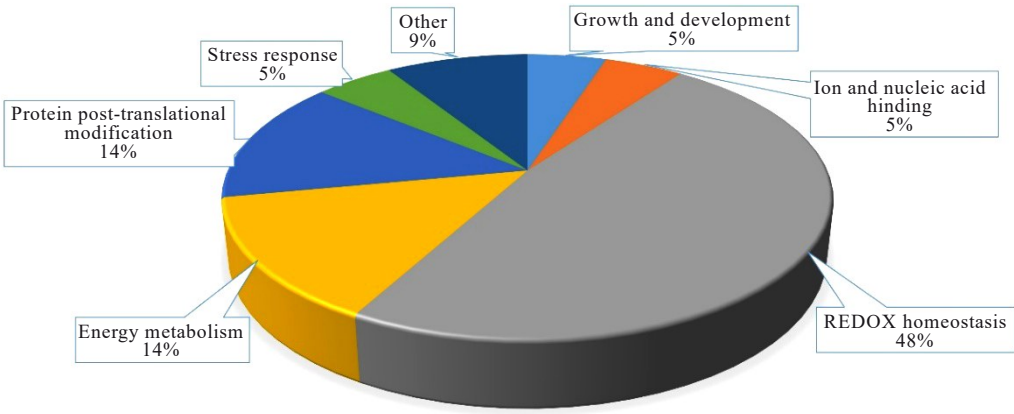


图4 各组果蝇脑组织中差异表达蛋白的功能分类

Fig.4 Functional classification of differentially expressed proteins in drosophila heads in various groups

表5 各组果蝇脑组织中SOD、CAT和GSH-Px活性及MDA水平

Tab.5 Activities of SOD, CAT, and GSH-Px, and MDA levels in heads of drosophila in various groups (n=100, $\bar{x} \pm s$)

Group	SOD [$\lambda_B/(U \cdot mg^{-1})$]	CAT [$\lambda_B/(U \cdot mg^{-1})$]	GSH-Px [$\lambda_B/(U \cdot mg^{-1})$]	MDA [$m_B/(\mu mol \cdot g^{-1})$]
Young	278.80±10.26	36.22±4.24	152.78±7.32	1.07±0.11
Aged	189.81±17.29*	19.39±1.95**	124.16±10.23**	1.58±0.11**
GEE	314.37±57.76 $\Delta\Delta$	33.96±2.32 $\Delta\Delta$	148.15±4.95 Δ	1.22±0.14 Δ

*P<0.05, **P<0.01 vs young group; Δ P<0.05, $\Delta\Delta$ P<0.01 vs aged group.

为探讨GEE改善老年相关睡眠障碍功效的相关机制,本研究利用基于2D-DIGE和MALDI-TOF-MS的蛋白质组学技术筛选并鉴定了GEE调控老年果蝇脑组织中的差异表达蛋白,并利用生物信息学方法对其功能进行了分类整理,结果表明:差异表达蛋白的功效主要与氧化还原平衡有关。研究^[15]表明:氧化还原系统与衰老进程存在紧密关联。氧化还原信号节律和经典节律调控机制之间直接耦合,通过控制神经元细胞离子通道电流直接打破睡眠节律稳态,在昼夜交替时对睡眠-觉醒周期起到重要作用^[16-18]。在睡眠过程中,氧化还原水平的变化还会影响脑部神经元活动、激素分泌和大脑皮层功能等多个方面,从而影响到人体的入睡和觉醒状态。基于蛋白质组学结果及上述研究结果,本文作者推测调控氧化还原平衡可能是GEE改善老年相关睡眠障碍功效的潜在机制。人参具有调控氧化还原平衡的功效^[19-21],人参中含有丰富的皂苷和多糖等活性成分,上述成分可以促进机体抵抗自由基对细胞的损害^[22-24],减轻氧化损伤引起的细胞老化和炎症反应^[25-27]。人参还能促进机体内抗氧化酶的活性,增强细胞自我修复能力,从而保护心血管和神经系统等重要器官免受氧化损伤^[28]。本研究果蝇脑组织中抗氧化系统相关酶活性及抗氧化/氧化物水平分析结果验证了本文作者推测:GEE通过调控氧化还原平衡改善老年相关睡眠障碍。

综上所述,GEE对老年相关睡眠障碍有改善作用,其作用机制与调控脑组织氧化还原平衡有关,本研究结果为进一步开发人参改善睡眠相关药物提供了思路,并为其临床应用提供了一定的实验依据。

利益冲突声明:

所有作者声明不存在利益冲突。

作者贡献声明:

刘建、陈雪楠和赵为民参与实验设计、蛋白质组学实验操作、论文撰写及论文审校,邢鹭和兰天野参与行为学数据分析及取材,姚璠、王雯和董玉福参与实验操作及数据分析,吴金普、毕然和孙立伟参与统计学分析及文献整理。

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