调查研究
Investigation

森林康养对人体身心健康影响研究的荟萃分析

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摘要：

[背景] 随着城市化的发展以及居住空间的扩张，生态环境和人类健康问题成为各界关注的热点。社会亚健康人群逐步扩大，各种心理、生理疾病逐渐呈低龄化发展，森林康养这种在自然中寻求健康的方式开始得到人们的关注。

[目的] 评价森林康养对部分身心健康指标的影响。

[方法] 检索国内外数据库（中国知网、万方数据库、中国生物医学文献服务系统、Web of science、ScienceDirect、PubMed、Embase 和 Cochrane Library）中森林康养的相关研究文献，时间范围为各数据库建库至 2023 年 1 月 31 日，提取相关数据进行荟萃分析，探究森林康养与人群心理、生理指标的关系。

[结果] 共纳入 85 篇文献，荟萃分析结果显示，森林组《心境状态量表》《正负情绪量表》《贝克抑郁量表》《状态-特质焦虑量表》评分优于城市组（$P<0.05$）；森林组收缩压、舒张压、心率、交感神经指标 [ln（LF/HF）]、唾液皮质醇以及血清炎性因子水平低于城市组，副交感神经指标 [ln（HF）] 水平高于城市组（$P<0.05$）。亚组分析表明，康养时长≤0.5 h 时心率（SMD=−1.62，95%CI：−2.41～−0.82）、ln（HF）（SMD=1.29，95%CI：0.73～1.85）、ln（LF/HF）（SMD=−1.49，95%CI：−2.13～−0.86）、唾液皮质醇（SMD=−0.53，95%CI：−0.81～−0.25）的变化更明显，>0.5~3 h 时情绪状态的恢复效果更佳（如紧张 SMD=−2.40，95%CI：−3.21～−1.59 等），>3 h 时收缩压（SMD=−0.53，95%CI：−1.03～−0.03）和舒张压（SMD=−0.42，95%CI：−0.88～0.04）的降低效果更好；静坐对《心境状态量表》各项指标的恢复更好（如疲劳 SMD=−2.26，95%CI：−3.07～−1.45 等），步行对血压（收缩压 SMD=−0.57，95%CI：−1.07～−0.06；舒张压 SMD=−0.72，95%CI：−1.36～−0.07）、心率等（SMD=−1.51，95%CI：−2.38～−0.64）生理指标的恢复更好；除血压外，青年人的康养效果普遍比中老年人好。

[结论] 森林康养能带给人放松、舒适的心理感受；能降低血压、心率，调节自主神经系统；减少压力激素的释放，降低血清炎症因子水平，对心血管、免疫系统方面的疾病具有辅助性的恢复作用。同时，康养时长、形式和受试者年龄对康养效果有一定影响。

关键词：森林康养；心理健康；生理健康；荟萃分析

Effects of forest therapy on human physical and mental health: A meta-analysis DUAN Guangmei, FAN Liwei, BU Wanning, LYU Jiaxin, CAI Yan (College of Forestry and Grassland, Jilin Agricultural University, Changchun, Jilin 130118, China)

Abstract:

[Background] With urbanization and residential space expansion, ecological environment and human health issues have become hot social topics. Forest health, as a way of seeking health in nature, has begun to receive public attention in the context of the gradually increasing sub-healthy population and various psychological and physical diseases at a young age.

[Objective] To systematically evaluate the effects of forest therapy on selected physical and mental health indicators.

[Methods] Relevant research literature was retrieved from domestic and international databases (China National Knowledge Infrastructure, Wanfang Database, China Biomedical Literature Service System, Web of Science, ScienceDirect, PubMed, Embase, and Cochrane Library), with a time range from database establishment to January 31, 2023. Relevant data were extracted for meta-analysis to explore the relationship between forest therapy and selected psychological and physiological indicators.

[Results] A total of 85 articles were included, and the meta-analysis results showed that better

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scores of Profile of Mood States, Positive and Negative Affect Scale, Beck Depression Inventory, and State Trait Anxiety Scale were found in the forest group than those in the urban group ($P<0.05$); the levels of systolic blood pressure, diastolic blood pressure, heart rate, sympathetic nerve indicator [ln (LF/HF)], salivary cortisol, and serum inflammatory factors were lower in the forest group than in the urban group, while parasympathetic nerve indicator [ln (HF)] level was higher in the forest group than in the urban group ($P<0.05$). The results of subgroup analysis showed that the changes in heart rate (SMD=−1.62, 95%CI: −2.41, −0.82), ln (HF) (SMD=1.29, 95%CI: 0.73, 1.85), ln (LF/HF) (SMD=−1.49, 95%CI: −2.13, −0.86), and salivary cortisol (SMD=−0.53, 95%CI: −0.81, −0.25) were more significant when the duration of forest therapy was ⩽ 0.5 h, the recovery effect on emotional state was better in the >0.5~3 h group (such as tension SMD=−2.40, 95%CI: −3.21, 1.59), and the reduction effects on systolic blood pressure (SMD=−0.53, 95%CI: −1.03, −0.03) and diastolic blood pressure (SMD=−0.42, 95%CI: −0.88, 0.04) were better in the > 3 h group. Seated meditation showed better recovery effects on multiple indicators of Profile of Mood States (such as fatigue SMD=−2.26, 95%CI: −3.07, −1.45), while walking showed better recovery effects on physiological indicators such as blood pressure (systolic blood pressure SMD=−0.57, 95%CI: −1.07, −0.06; diastolic blood pressure SMD=−0.72, 95%CI: −1.36, −0.07) and heart rate (SMD=−1.51, 95%CI: −2.38, -0.64). Except for blood pressure, the health benefits of forest therapy in the younger age group were generally better than those in the middle-aged and elderly group.

[Conclusion] Relaxed and comfortable psychological feeling is reported when practicing forest therapy; it can lower blood pressure and heart rate, regulate the autonomic nervous system; it can also reduce the release of stress hormones and lower serum levels of inflammatory factors, exerting an auxiliary recovery effect on cardiovascular and immune system disorders. At the same time, the therapy duration, form, and age of the subjects have a certain impact on the effects of forest therapy practice.

Keywords: forest therapy; mental health; physical health; meta-analysis

随着城市化的发展以及居住空间的不断扩张，生态环境和人类健康问题逐渐成为各界关注的热点。人们接触自然的机会越来越少，社会亚健康人群逐步扩大，各种心理、生理疾病逐渐呈低龄化发展[1]。在此背景下，森林康养这种在自然中寻求健康的方式开始得到人们的关注。森林康养是指利用丰富的森林资源，结合现有的医疗、康体服务设施，开展一系列保健疗养类活动[2]。近年来，国家和地方对森林康养的重视程度不断加强，政策支持越来越完善，清晰、全面地了解森林康养对人体健康的影响，对于未来森林康养的深入研究具有重要意义。

探究森林康养对人体健康的影响，一般采用随机对照法进行实验。国内关于森林康养对健康影响的荟萃分析较少，主要集中在对情绪状态影响的荟萃分析[3]。本研究拟通过收集森林康养的随机对照试验，从心理、生理两方面进行荟萃分析，系统评价森林康养对人体健康的功效，并进一步探索康养时长、形式和受试者年龄对康养效果的影响程度，为未来森林康养的理论研究和实践应用提供依据。

1 材料与方法

1.1 文献来源

应用中国知网、万方数据库、中国生物医学文献服务系统、Web of science、ScienceDirect、PubMed、Embase 和 Cochrane Library 进行检索，时间范围自建库以来至 2023 年 1 月 31 日，中文检索词包括森林康养、森林疗养、森林浴、森林疗愈、森林疗法等，英文检索词包括 forest therapy、Shinrin yoku、forest bathing、forest walking、forest viewing、natural therapy、exposure to nature。文献纳入标准如下：1）随机对照试验；2）试验组进行森林康养的相关活动，对照组在城市环境中进行相同活动或按照往常生活。同时，剔除对信息太少、数据缺失的文献。

1.2 分析方法

由研究组的两位成员共同进行文献筛选、数据提取，存在分歧时与第三方探讨解决。将检索结果导入 EndNote X9.1 软件删除重复文献，根据标题和摘要进行初筛，再对剩余文献阅览全文，判断是否纳入。数据提取内容包括：作者、国家、出版年份、样本人群特征、干预方式、结果等。将提取的数据按照干预时间分为短时间（⩽0.5 h）、中等时间（>0.5~3 h）、长时间（ > 3 h）三组，按照干预方式分为静坐观景、步行、其他（森林冥想、锻炼、综合森林浴计划等）三组，按照受试者年龄分为青年（18~35 岁）、中年（36~59 岁）、老年（60 岁以上）三组，后续进行亚组分析。

纳入的结局指标包括心理、生理两部分。心理指标包括：《心境状态量表》（Profile of Mood States, POMS）、《正负情绪量表》（Positive and Negative Affect Scale, PANAS）、《贝克抑郁量表》（Beck Depression Inventory, BDI），《状态-特质焦虑量表》（State Trait Anxiety Inventory, STAI）的指标。生理指标包括：收缩压、舒张压、心率、副交感神经指标 [ln（HF）]、交感神经指标 [ln（LF/HF）]、唾液皮质醇、血清炎性因子（白细胞介素-6、肿瘤坏死因子-α、超敏 C 反应蛋白）。

1.3 数据分析

文献中的表格数据可直接获取，图片数据采用 GetData Graph Digitizer 2.26 软件获取，使用 R-4.0.3 软件中的 meta 包进行数据分析。计量资料均为连续型资料，由于检测方法和单位不一致，因此用标准均值差（standardized mean difference, SMD）计算效应量。异质性较小时（I^2 < 50%且 P > 0.1），采用固定效应模型进行分析；异质性显著时（P≤0.1 或 I^2≥50%），采用随机效应模型进行分析，结果以 95%可信区间（confidence interval, CI）呈现。以 P < 0.05 代表差异有统计学意义。对各组研究进行敏感性分析，并通过漏斗图和 Egger 检验评估发表偏倚。

2 结果

2.1 纳入文献基本情况

本研究初检文献 36 720 篇，经过筛选最终纳入 85 篇文献[4–88]，筛选流程见图 1。纳入的文献主要分布在日本、中国、韩国三个亚洲国家，分别为 26、22、17 篇，少量分布在欧洲、北美和澳大利亚。

2.2 心理结局指标荟萃分析结果

POMS 包括紧张、忧郁、愤怒、疲劳、困惑、活力六个分量表，分别对其进行荟萃分析，总体异质性明显（I^2 > 50%, P < 0.001）。采用随机效应模型，结果显示（图 2），森林组紧张（SMD=−1.85，95%CI：−2.29~−1.40）、忧郁（SMD=−1.08，95%CI：−1.40~−0.77）、愤怒（SMD=−1.51，95%CI：−1.91~−1.10）、疲劳（SMD=−1.78，95%CI：−2.21~−1.35）、困惑（SMD=−1.31，95%CI：−1.70~−0.92）评分低于城市组，活力（SMD=1.44，95%CI：1.02~1.85）评分高于城市组，差异均有统计学意义（P < 0.05）。亚组分析显示（图 3），持续时长会影响情绪状态的恢复，疲劳（SMD=−1.89，95%CI：−2.28~−0.91）在 > 3h 时恢复效果最好，紧张（SMD=−2.40，95%CI：−3.21~−1.59）、忧郁（SMD=−1.25，95%CI：−2.10~−0.40）、愤怒（SMD=−1.98，95%CI：−2.98~−1.99）、困惑（SMD=−1.65，95%CI：−2.05~−1.25）、活力（SMD=1.82，95%CI：−1.10~2.52）在 0.5~3 h 时的恢复效果最好；静坐疗法更能有效缓解紧张（SMD=−2.46，95%CI：−3.43~−1.48）、忧郁（SMD=−1.53，95%CI：−2.29~−0.78）等负面情绪；青年人紧张（SMD=−2.16，95%CI：−2.73~−1.60）、愤怒（SMD=−1.80，95%CI：−2.35~−1.25）、疲劳（SMD=−2.10，95%CI：−2.66~−1.55）、活力（SMD=1.91，95%CI：1.37~2.44）指标恢复的幅度比中年人和老年人大。

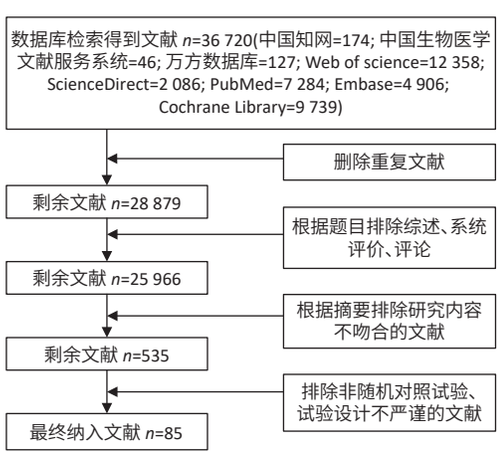
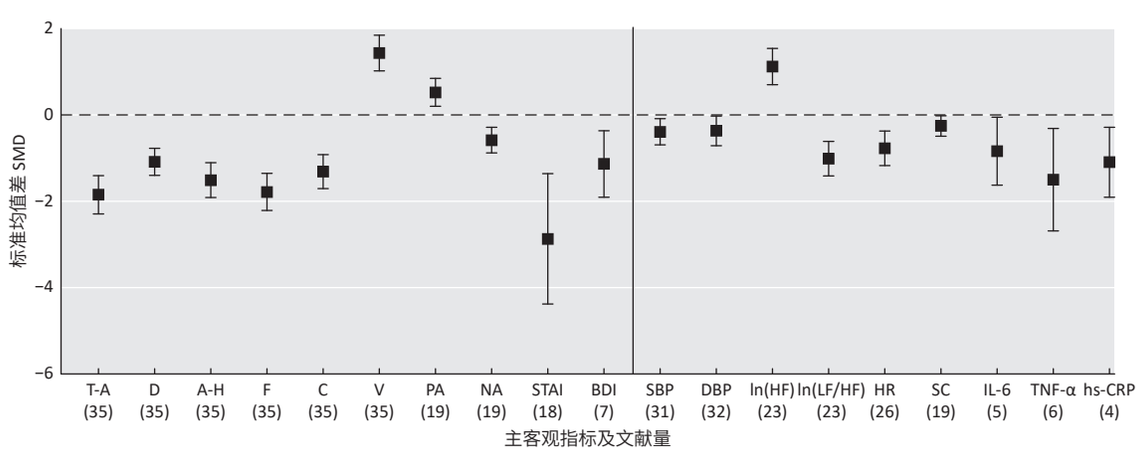


图 1 文献筛选流程图

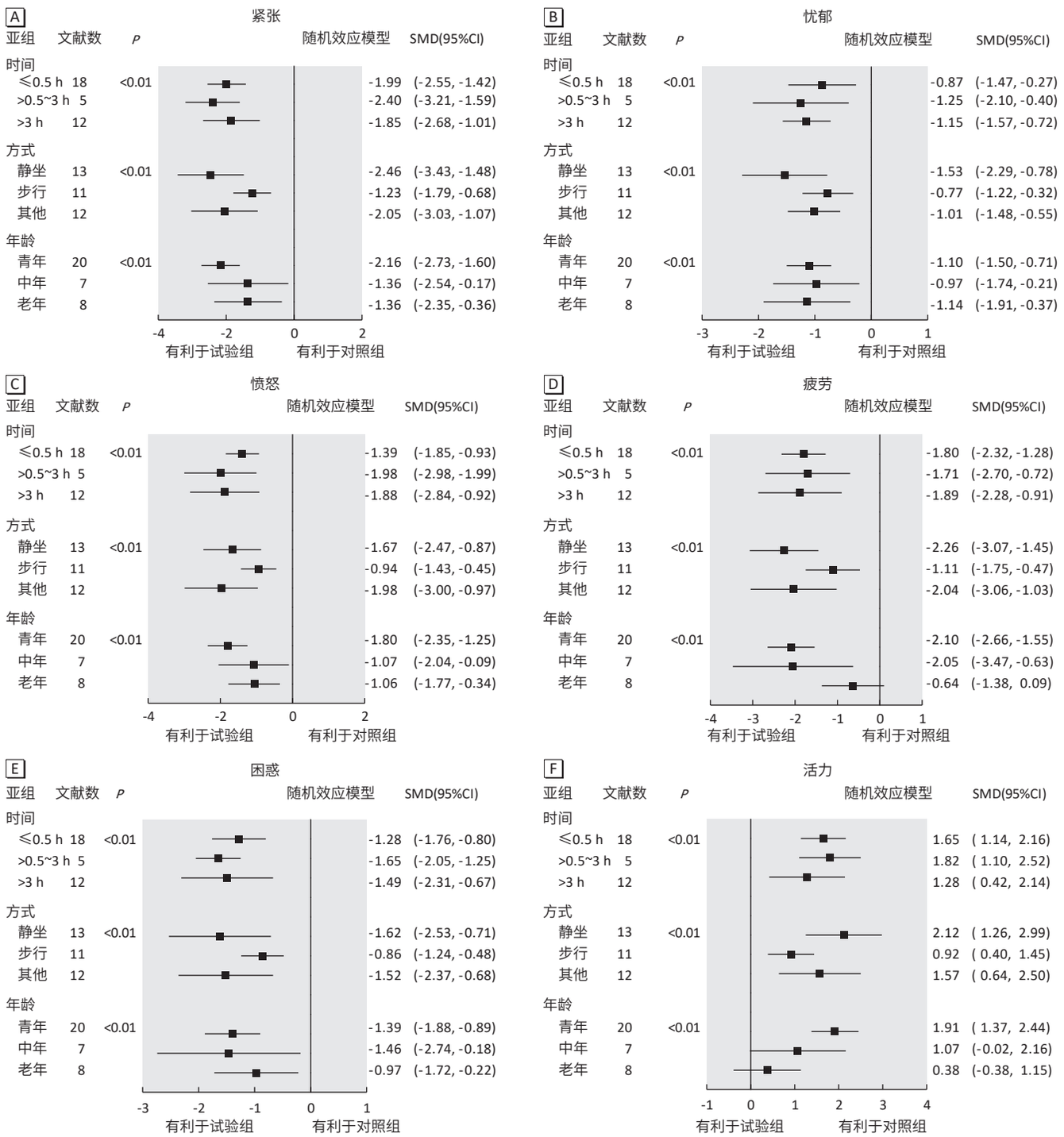
Figure 1 Flow chart of literature screening



[注] T-A：紧张（Tension or anxiety）；D：忧郁（Depression or dejection）；A-H：愤怒（Anger or hostility）；F：疲劳（Fatigue）；C：困惑（Confusion）；V：活力（Vigor）；PA：积极情绪（Positive affect）；NA：消极情绪（Negative affect）；STAI：状态-特质焦虑量表（State Trait Anxiety Inventory）；BDI：贝克抑郁量表（Beck Depression Inventory）；SBP：收缩压（Systolic blood pressure）；DBP：舒张压（Diastolic blood pressure）；ln（HF）：副交感神经指标；ln（LF/HF）：交感神经指标；HR：心率（Heart rate）；SC：唾液皮质醇（Salivary cortisol）；IL-6：白细胞介素-6（Interleukin-6）；TNF-α：肿瘤坏死因子-α（Tumor necrosis factor-α）；hs-CRP：超敏 C 反应蛋白（Hypersensitive C-reactive protein）。

图 2 不同主客观心理指标效应值

Figure 2 Effect values of included subjective and objective psychological indicators



[注] 从康养时长、方式、受试者年龄三个维度对 POMS 六个分量表紧张(A)、忧郁(B)、愤怒(C)、疲劳(D)、困惑(E)、活力(F)进行亚组分析。

图 3 心理指标亚组分析森林图

Figure 3 Subgroup analysis of psychological indicators by forest map

PANAS 分为积极情绪和消极情绪两部分。对于积极情绪，异质性检验结果为 I^2=85.7%，P<0.001，随机效应模型显示，森林组积极情绪评分高于城市组(SMD=0.53，95%CI：0.20~0.85)；对于消极情绪，异质性检验结果为 I^2=82.8%，P<0.001，随机效应模型显示，森林组消极情绪评分低于城市组(SMD=−0.58，95%CI：−0.88~−0.28)，见图 2。

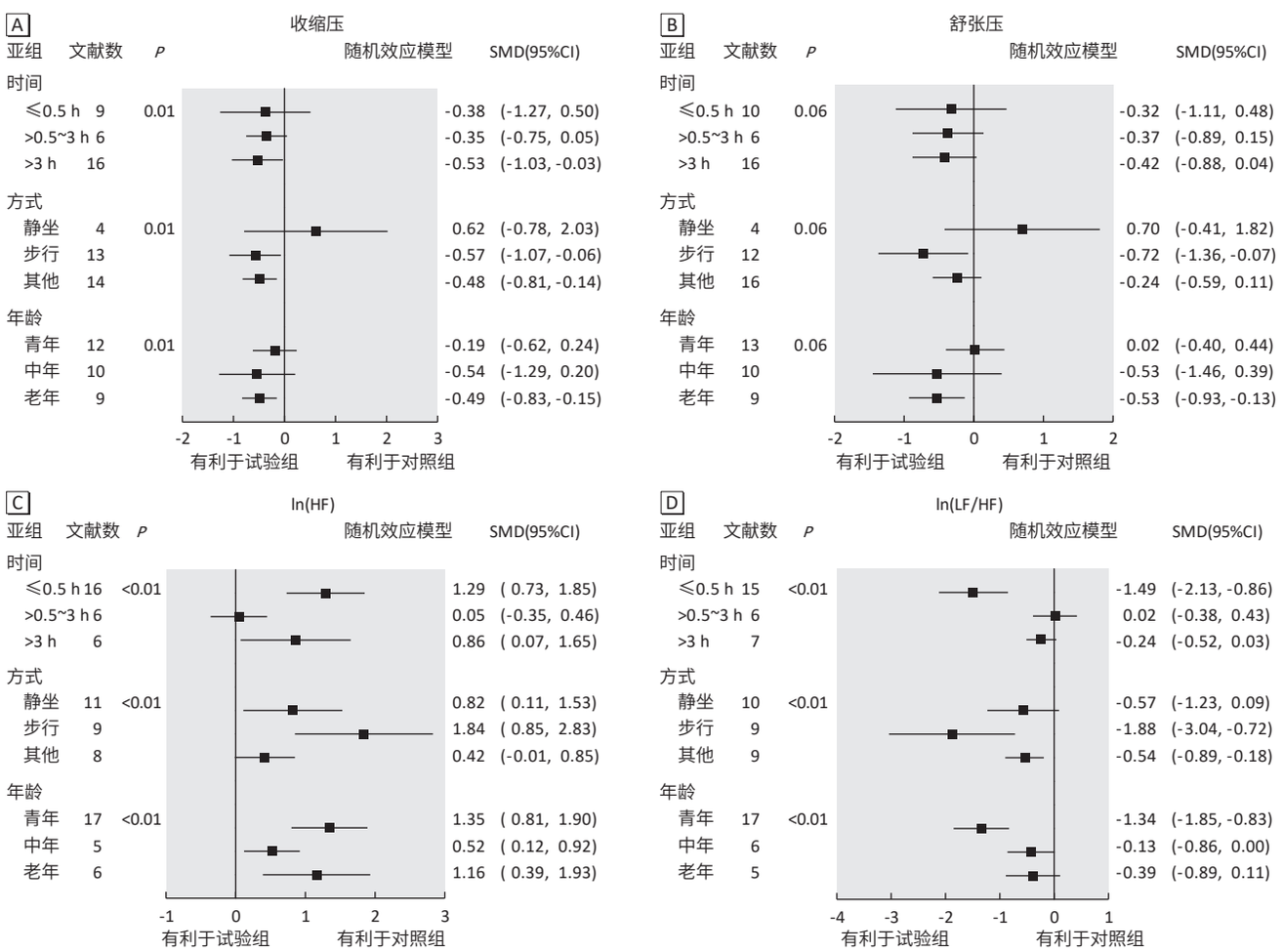
18 项研究荟萃分析的结果显示，森林组 STAI 评分低于城市组(SMD=−2.87，95%CI：−4.38~−1.36)；7 项研究荟萃分析的结果显示，森林组 BDI 评分低于城市组(SMD=−1.13，95%CI：−1.90~−0.36)，见图 2。

2.3 生理结局指标荟萃分析结果

血压包括收缩压和舒张压。对于收缩压，异质性检验结果为 I^2=91%，P=0.01，随机效应模型显示，森林组收缩压水平低于城市组（SMD=−0.08，95%CI：−0.39~−0.69）；对于舒张压，异质性检验结果为 I^2=93%，P=0.06，随机效应模型显示，森林组舒张压水平低于城市组（SMD=−0.33，95%CI：−0.67~−0.01），见图 2。亚组分析显示（图 4），时长 > 3 h 时降压效果更佳（收缩压：SMD=−0.53，95%CI：−1.03~−0.03；舒张压：SMD=−0.42，95%CI：−0.88~0.04）；步行的降压效果更好（收缩压：SMD=−0.57，95%CI：−1.07~−0.06；舒张压：SMD=−0.72，95%CI：−1.36~−0.07）；中年（收缩压：SMD=−0.54，95%CI：−1.29~0.20；舒张压：SMD=−0.53，95%CI：−1.46~0.39）和老年（收缩压：SMD=−0.49，95%CI：−0.83~−0.15；舒张压：SMD=−0.53，95%CI：−0.93~−0.13）的血压变化更明显。

28 篇文献测量了受试者的 ln（HF）和 ln（LF/HF）水平。对于 ln（HF），异质性检验结果为 I^2=91%，P < 0.001，随机效应模型显示，森林组的 ln（HF）结果高于城市组（SMD=1.12，95%CI：0.70~1.54）；对于 ln（LF/HF），异质性检验结果为 I^2=92%，P < 0.001，随机效应模型显示，森林组的 ln（LF/HF）结果低于城市组（SMD=−1.01，95%CI：−1.41~−0.61），见图 2。亚组分析显示（图 4），时长≤0.5 h时 ln（HF）（SMD=1.29，95%CI：0.73~1.85）和 ln（LF/HF）（SMD=−1.49，95%CI：−2.13~−0.86）的变化最明显；步行对 ln（HF）（SMD=1.84，95%CI：0.85~2.83）和 ln（LF/HF）（SMD=−1.88，95%CI：−3.04~−0.72）结果的影响较大；青年人的恢复效果更好（ln（HF）：SMD=1.35，95%CI：0.81~1.90；ln（LF/HF）：SMD=−1.34，95%CI：−1.85~−0.83）。

32 篇文献测量了受试者的心率，异质性检验结果为 I^2=91%，P < 0.001，随机效应模型显示，森林组的心率低于城市组（SMD=−0.77，95%CI：−1.17~−0.37），见图 2。亚组分析显示（图 4），时长≤0.5 h 时心率的降低效果最好（SMD=−1.62，95%CI：−2.41~−0.82）；步行更能明显降低心率（SMD=−1.51，95%CI：−2.38~−0.64）；青年人的心率降低幅度最大（SMD=−1.78，95%CI：−2.89~−0.67）。



[注] 从康养时长、方式、受试者年龄三个维度对收缩压(A)、舒张压(B)、ln(HF)(C)、ln(LF/HF)(D)、心率(E)、唾液皮质醇(F)进行亚组分析。

图 4 生理指标亚组分析森林图

Figure 4 Subgroup analysis of physiological indicators by forest map

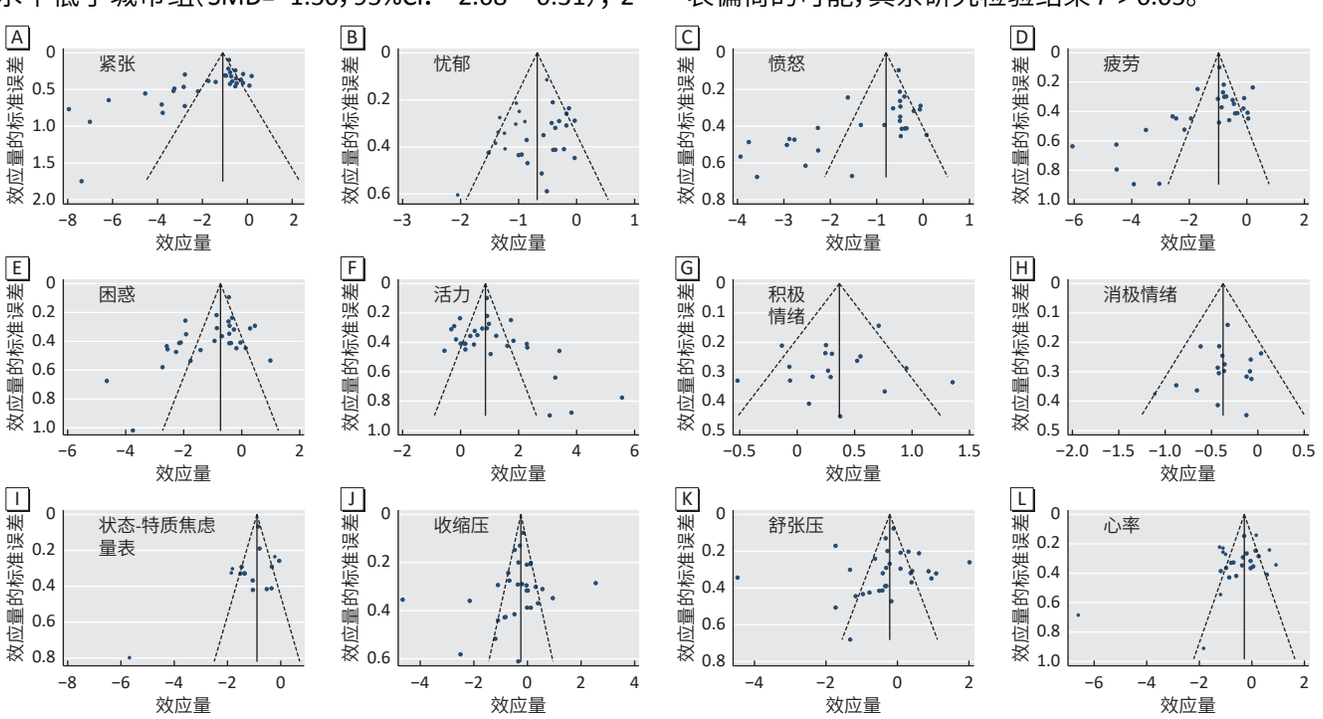
19 篇文献测量了受试者的唾液皮质醇水平，异质性检验(I^2=91%，P=0.000 2)，随机效应模型显示，森林组的唾液皮质醇水平低于城市组(SMD=−0.25，95%CI：−0.49~−0.02)(图 2)。亚组分析显示(图 4)，时长≤0.5 h 时 SC 的变化最明显(SMD=−0.53，95%CI：−0.81~−0.25)；步行更能明显降低 SC 水平(SMD=−0.49，95%CI：−1.27~0.30)；青年人的变化幅度最大(SMD=−0.39，95%CI：−0.69~−0.08)。

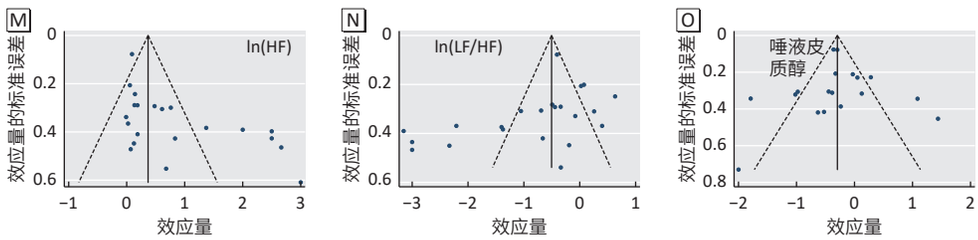
对于血清炎性因子(图 2)，5 篇文献荟萃分析的结果显示，森林组的白细胞介素-6 水平低于城市组(SMD=−0.84，95%CI：−1.62~−0.05)；森林组肿瘤坏死因子-α 水平低于城市组(SMD=−1.50，95%CI：−2.68~−0.31)；2 篇文献荟萃分析的结果显示，森林组超敏 C 反应蛋白含量比城市组低(SMD=−1.09，95%CI：−1.90~−0.28)。

2.4 敏感性分析与发表偏倚

通过依次去除单篇文献，观察合并结果是否改变来进行敏感性分析，各组荟萃分析的结果前后没有显著变化，提示稳定性较好。

对纳入文献超过 10 篇的指标绘制漏斗图评估发表偏倚(图 5)，除忧郁、消极情绪、STAI、心率外，其余漏斗图均略有不对称，提示存在发表偏倚。对剩余指标进行 Egger 检验，有 2 组研究的检验结果(白细胞介素-6：P=0.043，肿瘤坏死因子-α：P=0.015)提示存在发表偏倚的可能，其余研究检验结果 P > 0.05。





[注] 对纳入文献超过 10 篇的指标紧张(A)、忧郁(B)、愤怒(C)、疲劳(D)、困惑(E)、活力(F)、积极情绪(G)、消极情绪(H)、状态-特质焦虑量表(I)、收缩压(J)、舒张压(K)、心率(L)、ln(HF)(M)、ln(LF/HF)(N)、唾液皮质醇(O)绘制漏斗图。

图 5 各项结局指标漏斗图

Figure 5 Funnel chart of selected outcome indicators

3 讨论

森林康养对人群健康的影响是近年来的研究热点之一。已有较多学者在世界不同城市，针对不同人群展开研究，并取得一定成果。本研究基于 85 篇文献的研究结果对森林康养与人群健康的关系进行荟萃分析，结果表明，森林环境能带给人放松、舒适的心理感受；还能降低血压、心率，调节自主神经系统；减少压力激素的释放，降低血清炎症因子水平，对心血管、免疫系统方面的疾病有一定的恢复作用。

本研究通过亚组分析发现，康养时长、形式和受试者年龄对康养效果有一定影响。康养时长较短时，心率变异性相关指标和唾液皮质醇的变化比其他时段更明显；时长为 0.5~3 h 时对紧张、焦虑等负面情绪的调节效果最佳；而长期的森林康养对血压的降低效果更明显。此外，本研究发现静坐对情绪状态的恢复更佳，步行对血压、心率等生理指标的恢复更好，这与既往研究一致[89]。未来的研究可以在森林中进行更多的活动，如森林瑜伽、冥想等来进一步对比不同活动类型的影响差异。在受试者年龄方面，除了中老年人的降压效果更明显外，其余主客观指标均是青年人的恢复效果更好，这可能由于青年人血压方面相对健康，且身体机能的恢复能力更强[90]。

本研究纳入的文献中，使用最多的心理指标为 POMS，其次为 PANAS，这两个量表适用于普通受试者的情绪自测，而针对焦虑症、抑郁症等特定患者，一般使用 STAI、BDI。血压和心率变异性是常见的生理指标，其余指标针对不同人群有所区别，例如针对压力人群研究了压力激素的变化，针对心血管疾病患者进行血清炎性因子的测定，针对免疫疾病患者进行免疫细胞活性的测定等。大部分研究结果显示，森林康养对心理指标的影响更为显著，对生理指标的影响较小甚至不明显，表明森林康养是恢复心理健康的重要手段，而对一些生理指标只能起到辅助恢复的效果。

通过对纳入文献的梳理可以发现，虽然近年来森林康养在研究角度上逐渐丰富，但大部分研究存在研究时间短、大样本量研究少、心理生理数据单一等问题。其中，针对森林环境放松作用的研究较多，基本使用简式量表、脑电波测定等方式，研究方法和技术创新不足。未来可以将创新的问卷设计、眼动追踪、无创生理参数的测量等心理、生理多维度的研究方法应用到森林康养研究中。此外，已发表的研究在实验严谨性方面也存在一些不足，例如，森林康养的特点使其在实验过程中难以施行盲法，增加了偏倚风险；实验过程中安全性方面的不良事件(如花粉过敏等)在纳入的研究中没有详述。

本研究存在以下局限：荟萃分析的质量好坏受原始文献的影响较大，而本研究未根据原始文献质量选择是否纳入；一些研究数较少的指标未进行荟萃分析；本研究尚分析森林中不同林分对康养效果的影响。

综上所述，森林康养在一定程度上对心理、心血管系统、神经系统等方面疾病具有辅助性的恢复效果，目前相关研究在指标选取和研究技术上有待创新。同时，未来研究需完善相关指标系统和追加研究样本，进一步验证不同时长、形式、林分等因素对康养效果的影响，为人群自主选择和疗养师合理制定森林康养方案提供科学依据。

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