刺梨原汁干预对运动生理机能的影响及其作用机制研究

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摘 要：目的：系统梳理近年来刺梨原汁及其多酚、多糖、黄酮、维生素 C 和发酵产物等成分对运动表现、氧化应激、炎症反应、能量代谢、组织保护及脑-肠轴的影响，探讨其潜在机制和应用边界。方法：以 PubMed、中国知网（CNKI）和 Google Scholar 为主要检索来源，围绕刺梨（Rosa roxburghii）、运动（exercise）、疲劳（fatigue）、氧化应激（oxidative stress）、恢复（recovery）等关键词检索相关文献。结果：刺梨原汁富含多酚、黄酮、多糖和维生素 C 等活性成分，可通过抗氧化、抗炎、能量代谢调节、肠道微生态维持及组织保护等多重途径影响运动相关生理过程。结论：刺梨原汁在运动营养中具有潜在应用价值，但高质量临床证据仍不足，未来需加强随机对照试验研究。

关键词：刺梨原汁；运动表现；氧化应激；疲劳；恢复

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一、前言

运动训练和竞技活动往往伴随能量消耗加剧、活性氧水平升高、微损伤累积以及炎症反应波动。这些生理变化既是训练适应的重要信号，也可能在恢复不足或负荷管理失当的情况下演变为疲劳积累、运动表现下降和组织损伤[1,2]。近年来，天然植物活性成分在运动营养、免疫调节、恢复管理和代谢支持中的价值受到越来越多关注[3,4]。刺梨原汁富含多酚、黄酮、维生素 C、有机酸和多糖等成分，被认为在抗氧化、抗炎、能量代谢调节、肠道稳态维持以及肝肺肠等组织保护方面具有多重潜力[5-10]。

从已有文献来看，刺梨原汁及其发酵产物、果渣提取物和多糖组分对多种生理过程的影响正在被逐步揭示[11-16]。研究者不仅关注其直接的抗氧化和抗炎能力[17,18]，也在探索其对肠道菌群结构、短链脂肪酸生成、肠屏障功能以及脑-肠轴信号的调节作用[19-22]。值得注意的是，刺梨原汁中的多酚类物质包括鞣花酸、槲皮素及其糖苷、芦丁等多种黄酮醇类化合物，这些成分在抗氧化通路中具有互补作用[23-25]。多糖类成分则被证实能够调节免疫应答和肠道屏障功能[26-28]。

在运动科学领域，氧化应激与炎症反应被视为训练适应和过度训练之间的关键调节因素。适量的活性氧生成有助于激活信号通路并促进适应，而过量的氧化应激则可能引发脂质过氧化、DNA 损伤和蛋白质降解，最终影响运动表现和恢复速度[1,2]。因此，寻找既能支持抗氧化防御又不完全抑制适应信号的天然营养策略，一直是运动营养研究的重要方向[29,30]。刺梨原汁因其多成分、多靶点的特点，在这一领域展现出独特价值[5-10]。本综述旨在系统梳理近年来刺梨原汁干预与运动相关研究的主要进展，围绕其活性成分、潜在机制、动物与细胞实验证据以及应用前景展开讨论[31,32]。

（一）资料与方法

本研究采用叙述性文献综述方法，重点梳理刺梨原汁及其相关制剂在运动生理、氧化应激、炎症反应、能量代谢、肠道微生态与组织保护等方面的最新研究进展。检索数据库主要包括 PubMed、CNKI 和 Google Scholar，并辅以高被引研究和重要综述的追踪[31-33]。中文检索词包括刺梨、刺梨原汁、运动、疲劳、氧化应激、恢复、等；英文检索词包括 Rosa roxburghii、CiLi、exercise、oxidative stress、fatigue、recovery 等。

纳入标准为与刺梨成分、干预效果或运动相关机制有关的研究型文献与综述，优先选择 2018 年以后发表的成果。排除标准包括重复发表、与刺梨或运动无关的文献、会议摘要以及无法获取全文的条目。最终纳入 47 篇

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文献，涵盖动物模型、细胞实验和部分人体观察性研究[34,35]。

二、刺梨原汁的主要活性成分

（一）多酚与黄酮类化合物

刺梨原汁中富含多种酚类化合物，包括鞣花酸、鞣花单宁、槲皮素及其糖苷、芦丁等。研究表明，这些成分能够通过清除 DPPH 自由基、ABTS 自由基和超氧阴离子等途径发挥抗氧化作用，同时抑制脂质过氧化链式反应[23-25,36]。在细胞模型中，刺梨黄酮能够显著降低辐射诱导的胸腺细胞凋亡率和炎症因子表达水平[1]。此外，鞣花单宁被发现能够抑制 Poly(I:C)诱导的人角质形成细胞 IL-8 释放，提示其在调节皮肤免疫应答中的潜在价值[2]。

（二）多糖类成分

刺梨果实多糖是另一类重要的生物活性成分。研究显示，刺梨多糖具有体内外抗氧化活性，可作为天然抗氧化剂的潜在来源[37]。在代谢调节方面，刺梨多糖能够改善 db/db 糖尿病小鼠的高血糖和高脂血症，并调节结肠微生态组成[5]。在肠道健康方面，刺梨多糖被发现可以调节肠道菌群结构，增加有益菌丰度，改善高脂饮食引起的肠道屏障损伤和炎症反应[6,26,28]。这些发现为多糖在运动恢复和肠道健康管理中的应用提供了重要参考[19,20]。

（三）维生素 C 与发酵产物

刺梨被誉为"维 C 之王"，其果实中维生素 C 含量在常见水果中名列前茅。维生素 C 作为经典的抗氧化营养素，在胶原蛋白合成、免疫功能维持和铁吸收促进等方面发挥重要作用，这些功能均与运动表现和恢复密切相关[38]。发酵刺梨果汁被发现能够通过调节肠道菌群和代谢产物改善高脂血症[9]，而发酵处理还可改变果汁中活性的组成和生物可利用度[39]。刺梨果渣中的溶解性膳食纤维被发现对 DSS 诱导的溃疡性结肠炎具有保护作用[10]。

三、刺梨原汁的主要活性成分

（一）抗氧化与抗炎机制

运动过程中活性氧水平升高会引发脂质过氧化、蛋白质损伤与线粒体功能下降，进而影响恢复效率[1,2]。多项研究显示，刺梨多酚、黄酮及发酵产物可通过 Nrf2、AMPK、NF-kB 等通路减轻氧化应激和炎症反应[17,18,40]。刺梨原汁被发现能够抑制 NF-kB 信号通路并增加 IL-2 表达, 从而调节外周血中 Foxp3 介导的 Tregs 平衡[12]。Tang 等通过整合蛋白质组学和代谢组学方法，系统揭示了刺梨果实多酚对急性肝损伤的改善机制[41]。此外，刺梨果汁对砷诱导的肝损伤中组蛋白 H3K18 乙酰化依赖性抗氧化通路的抑制作用也被阐明[14]。这些分子机制的发现为高强度训练后炎症管理和免疫调节提供了理论支持。

（二）能量代谢与疲劳控制

刺梨活性成分可能通过调节 AMPK 信号通路和线粒体功能影响能量代谢, 涉及脂肪酸氧化和糖代谢过程[5,15]。刺梨苷类和槲皮素对 D-半乳糖诱导衰老模型的线粒体功能改善提示其在延缓运动疲劳中的潜在价值[42]。Wu 等发现刺梨果实的醇水提取物对高脂饮食大鼠的高脂血症具有改善作用，提示其在代谢调节中的价值[15]。这些结果为理解刺梨在运动场景中支持能量代谢的潜力提供了分子层面的依据。

（三）肠道微生态与脑-肠轴调节

刺梨多糖可调节肠道菌群组成、增加短链脂肪酸生成并增强肠屏障功能，这些效应可能通过脑-肠轴影响运动恢复[6,19-22]。Wang 等的研究揭示了刺梨多糖的益生元特性及其对肠道屏障的保护机制[6]。Li 等发现刺梨果渣溶解性膳食纤维对 DSS 诱导的溃疡性结肠炎小鼠具有保护作用，其机制涉及血清代谢调节和 NF-kB 通路抑制[10]。Li Xingjie 等进一步证实刺梨果实提取物通过调节肠道菌群和 IL-17 信号通路预防溃疡性结肠炎[43]。这些证据共同表明，刺梨原汁及其衍生物在肠道健康管理中具有重要价值，而肠道健康又与运动恢复密切相关[6,28]。

（四）肝脏、肺与神经组织保护作用

除肠道保护外，刺梨成分在肝脏、肺和神经组织保护方面也显示出潜力。多项研究证实刺梨原汁及其多酚对砷诱导肝损伤的保护作用[14,18,44]，其机制涉及 Nrf2/GPX4 介导的氧化应激调控[20]。在肺保护方面，Tang 等通过网络药理学和代谢组学方法揭示了刺梨多酚治疗急性肺损伤的新策略[45]。在神经保护方面，刺梨活性成分 Kaji-Ichigoside F1 通过 BDNF/Akt/mTOR 信号通路发挥神经保护作用[46]。这些结果提示刺梨原汁可能通过减轻系统性炎症和氧化损伤为运动人群的恢复管理提供额外支持。

四、研究现状与证据

（一）动物实验证据

从整体证据结构来看，刺梨原汁相关研究正在由成分表征和体外活性验证逐步转向动物模型中的机制研究和系统生物学分析[5-10]。在动物层面，多项研究观察到刺梨干预可改善代谢紊乱模型的血糖血脂水平，缓解氧化应激并改善肠道菌群组成[5,6,15,26]。Song 等的肝脏蛋白质组学研究为刺梨的代谢调节作用提供了系统层面的证据[16]。Ji 等报道发酵刺梨果汁可改善高脂饮食小鼠的代谢紊乱[40]。Wei 等发现副干酪乳杆菌发酵的刺梨果汁对链脲佐菌素诱导的 2 型糖尿病小鼠具有改善作用[47]。这些结果为理解刺梨在运动场景中的潜在价值提供了丰富的基础数据。

（二）细胞实验证据

细胞层面的研究为刺梨原汁的分子机制提供了更为精细的证据。Xu 等在小鼠胸腺细胞中观察到刺梨黄酮对辐射诱导的凋亡和炎症反应的保护作用[1]。Takayama 等发现鞣花单宁能抑制 Poly(I:C)诱导的 IL-8 产生[2]。Yuan 等报道了刺梨发酵果汁对 UVA 诱导的人胚皮肤成纤维细胞光老化的保护机制[29]。这些结果虽然距离运动干预仍有转化鸿沟，但有助于解释刺梨原汁在高氧化应激环境下的潜在作用逻辑。近年来的研究越来越倾向于使用多组学技术（如蛋白质组学、代谢组学和转录组学）来揭示刺梨的分子机制，这为从整体层面理解其生物学效应提供了新的方法学支撑[13,16,28]。

五、研究现状评价

现有文献显示，刺梨原汁在运动相关领域的研究仍以动物与细胞机制研究为主[5-10,17,18]，直接面向健康运动人群的随机对照试验较为有限。多数研究存在样本量小、干预周期短、剂量标准化不足及异质性较强等局限[31-35]。此外，不同来源的刺梨制品在活性成分含量、加工方式与生物利用度方面差异明显，导致跨研究比较难度较大[36,38,39]。

另一个值得关注的问题是，现有研究普遍缺乏与运动生理学指标的直接对接。例如，关于最大摄氧量、乳酸阈、肌肉损伤标志物、恢复时间、主观疲劳感等指标的研究仍然不足[1,2,29,30]。这使得刺梨原汁在运动场景中的价值目前更多停留在潜在支持策略层面，尚不足以形成明确的训练应用指南。在方法学层面，部分研究的实验设计存在一定的改进空间，例如缺乏阳性对照或安慰剂对照[34,35]。

六、应用前景与实践建议

在运动实践中，刺梨原汁更适合作为综合营养管理的一部分，而非单一干预手段。考虑到其抗氧化、抗炎、代谢调节与肠道保护潜力，训练强度较高、恢复窗口紧张或饮食结构偏单一的运动人群可能更值得关注[1,2,29,30]。其应用形式可包括原汁、发酵果汁、标准化提取物或与其他营养素搭配的复合配方[3,4,9]。在补充时机方面，训练前后的抗氧化补充策略以及日常膳食中的营养强化均值得探索。

然而，在实际推广前仍需解决几个关键问题：一是明确最佳剂量与补充时机；二是评估长期使用的安全性与依从性；三是建立与运动表现、恢复质量和免疫指标直接相关的临床证据[31-35]。此外，还应关注不同人群（耐力项目、力量项目、大众健身等）的差异性反应，以便制定更加个性化的运动营养建议。从产业发展角度来看，刺梨原汁作为中国特色水果资源，在功能性食品开发和运动营养品市场中具有独特的地理和文化优势[38,39]。

七、结论

综合现有文献，刺梨原汁干预在运动促进和恢复管理中具有较好的理论基础。其多酚、黄酮、多糖和维生素 C 等成分可能通过抗氧化、抗炎、能量代谢调节、肠道微生态维持与组织保护等多重途径影响运动相关生理过程[5-22]。然而，现有证据仍以动物与细胞研究为主，临床研究不足、剂量方案不统一、机制链条不完整等问题仍然突出[31-35]。未来研究应更加重视高质量随机对照试验、剂量-效应关系、补充时机、长期安全性及运动生理学核心指标的系统评估。

从应用转化的角度来看，刺梨原汁作为一种富含多种生物活性成分的天然饮品，在运动营养补充策略中具有独特优势。其多成分、多靶点的作用特点使其在应对运动引起的多重生理应激时可能具有协同效应[5-10]。同时，刺梨作为中国特色水果资源，在功能性食品开发和运动营养品产业化方面具有广阔的市场前景[38,39]。随着多组学技术的深入应用和更多高质量临床研究的开展，刺梨原汁在运动科学领域的应用价值有望得到更为充分的验证和认可[13,16,28]。

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Effect of Rosa roxburghii Tratt juice intervention on exercise physiological function and its mechanism

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Abstract:Objective: to systematically review the effects of Rosa roxburghii Tratt juice and its polyphenols, polysaccharides, flavonoids, vitamin C and fermentation products on exercise performance, oxidative stress, inflammatory response, energy metabolism, tissue protection and brain gut axis in recent years, and to explore its potential mechanism and application boundary. Methods: PubMed, China National Knowledge Infrastructure (CNKI) and Google Scholar were used as the main search sources, and the related literatures were searched around Rosa roxburghii, exercise, fatigue, oxidative stress, recovery and other keywords. Results: Rosa roxburghii Tratt juice was rich in polyphenols, flavonoids, polysaccharides, vitamin C and other active ingredients, which could affect the physiological process related to exercise through antioxidant, anti-inflammatory, energy metabolism regulation, intestinal microecology maintenance and tissue protection. Conclusion: Rosa roxburghii Tratt juice has potential application value in sports nutrition, but high-quality clinical evidence is still insufficient, and randomized controlled trials should be strengthened in the future.

Keywords:Rosa roxburghii Tratt juice; Athletic performance; Oxidative stress; Fatigue; Recovery