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不同强度运动水平对维持性血液透析患者炎症、营养及心脑血管事件的影响

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摘　要

慢性肾脏病是全球范围内的重大健康问题，患病率逐年上升。维持性血液透析(MHD)是终末期肾病患者的主要替代治疗方法。MHD患者常伴有微炎症状态、营养不良及心脑血管事件的高发风险。本文综述了不同强度运动对MHD患者炎症、营养及心脑血管事件的影响，旨在为MHD患者的运动处方制定提供理论依据。研究表明，低强度和中强度运动均能有效改善MHD患者的炎症状态、营养状况及心脑血管健康，而高强度运动的可行性和安全性仍需进一步研究。

关键词

维持性血液透析，运动强度，炎症，营养不良，心脑血管事件

The Impact of Different Exercise Intensities on Inflammation, Nutrition, and Cardiovascular Events in Maintenance Hemodialysis Patients

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Abstract

Chronic kidney disease (CKD) is a significant global health issue, with its prevalence increasing

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annually. Maintenance hemodialysis (MHD) is the primary replacement therapy for patients with end-stage renal disease. MHD patients often experience a state of micro-inflammation, malnutrition, and a high risk of cardiovascular and cerebrovascular events. This article reviews the effects of different exercise intensities on inflammation, nutrition, and cardiovascular events in MHD patients, aiming to provide a theoretical basis for the development of exercise prescriptions for MHD patients. Studies have shown that both low-intensity and moderate-intensity exercises can effectively improve the inflammatory state, nutritional status, and cardiovascular health of MHD patients, while the feasibility and safety of high-intensity exercise require further research.

Keywords

Maintenance Hemodialysis, Exercise Intensity, Inflammation, Malnutrition, Cardiovascular and Cerebrovascular Events

1. 引言

慢性肾脏病(chronic kidney disease, CKD)是全球范围内的重大健康问题，患病率逐年上升。据估计，我国约有 8200 万成年 CKD 患者[1]。维持性血液透析(maintenance hemodialysis, MHD)是 CKD 进展至终末期肾病(end stage kidney diseases, ESKD)的主要替代治疗方法。MHD 患者由于肾脏功能丧失，体内代谢废物潴留、激素失衡，常处于微炎症状态，且营养不良发生率较高，心脑血管疾病是其主要的致死、致残原因[2]。生活方式的干预对 ESKD 患者尤为重要，适宜的运动不仅有助于改善患者的生理功能，还能对其炎症、营养代谢及心血管系统产生潜在的调节作用，且不同强度运动带来的影响各异[3] [4]。目前，不同强度运动水平对 MHD 患者的影响尚未引起足够重视。本文将探讨不同强度运动水平对 MHD 患者炎症、营养及心脑血管事件的影响，为 MHD 患者长期运动处方的制定提供参考。

2. 维持性血液透析患者的炎症、营养与心脑血管问题现状

MHD 患者由于肾脏功能丧失，体内代谢废物潴留、激素失衡，常处于微炎症状态。患者体内促炎和抗炎标志物间的平衡失调，促炎细胞因子(如 TNF-α、IL-1、IL-6 等)水平升高[2]。CKD 背景下的低度系统性炎症受尿毒症进展、血脂异常、代谢综合征、肠道菌群失调、营养不良等多种因素刺激而持续激活。MHD 患者普遍存在营养不良状态，炎症状态的持续与饮食和营养不足相关。持续的炎症状态可导致患者食欲减退、蛋白质分解代谢增加，促使营养不良的发生。炎症和营养不良状态相互影响，形成恶性循环，激活凝血系统、损伤血管内皮，引起各种负面下游效应，增加 MHD 患者心脑血管事件的发生风险[2]。

3. 运动疗法在维持性血液透析患者中的进展

大量研究表明，运动对 MHD 患者具有多方面的益处。运动可通过多种机制改善 MHD 患者的慢性炎症、心血管功能，并对肌肉骨骼力量、代谢标志物、贫血、营养状态、情绪及睡眠产生积极影响[5]。运动疗法(Exercise Therapy, ET)由美国运动医学学院和运动医学协会提出，旨在针对特定患者进行运动评估并为其制定标准的疾病预防或治疗模式。MHD 患者的完整运动方案应包括运动类型、持续时间、强度、频率等。如何制定最适合 MHD 患者的运动处方目前仍在探索中，对 MHD 患者运动处方的制定应该遵循

个体化的原则，国内外许多研究干预的运动方案提示我们，不同的运动处方也许能带来不同的健康收益。目前，对 MHD 患者制定运动处方的频率和持续时间最多的分别是 3 次/周和每次 30~60 min，持续 3~6 月的规律训练[7]。运动方式集中在单一方式的有氧运动、阻抗运动或两者联合运动，此外还有间歇性训练、灵活性及柔韧性运动如瑜伽、八段锦等多种运动方式[6]。关于运动强度，大多数运动方案采用主观评估方法，如通过 RPE (Borg 量表)自主劳累感觉分级量表，并以中等截断值进行规定[7]。此外，还有些研究用代谢当量(Metabolic equivalent, METs)量化运动强度，METs 是以安静且坐位时的能量消耗为基础，表达各种活动时相对能量代谢水平的常用指标，可用于评估心肺功能[8] [9]。

4. 低、中强度运动对 MHD 患者炎症状态的影响

目前尚无统一的评估 MHD 患者微炎症状态的标准方法。营养不良－炎症评分(Malnutrition Inflammation Score, MIS)结合了临床症状、体格检查、营养相关实验室指标等多个维度，全面反映了患者的营养及炎症状况，常用于评估 ESKD 患者的营养状况及炎症风险[10] [11]。部分实验室指标如超敏 C 反应蛋白(hs-CRP)、C 反应蛋白(CRP)、白介素-6 (IL-6)、肿瘤坏死因子-α (TNF-α)、白介素-1β (IL-1β)和中性粒细胞与淋巴细胞比值(NLR)等均是临床常用的炎症标志物。

4.1. 低强度运动对炎症的影响

Huagang Hu 等人[12]从中国 74 个透析室招募了 827 名患者，发现低强度运动如慢走、简单的关节活动操等，能适度调节 MHD 患者的炎症状态。运动强度与健康相关生活质量存在显著相关性。Emilie Ford 等人[13]在加拿大开展的一项多中心临床研究发现，应用运动康复计划改善血液透析患者的症状负担，可能从长远来看改善生活质量并减少残疾发病率。低强度运动可促进血液循环，加速炎性介质的清除，减少局部炎症因子聚集[14]-[16]，提示低强度运动在抑制炎症慢性进展方面有一定作用。

4.2. 中强度运动对炎症的影响

中等强度运动，如快走、骑自行车等，相较于低强度运动，对炎症的调控更为显著[17]。它能激活机体自身的抗炎机制，促使巨噬细胞从促炎的 M1 表型向抗炎的 M2 表型转化，大量分泌抗炎细胞因子如 IL-10，制衡过度的炎症反应[18] [19]。Marta Gomarasca 等人[20] [21]的临床随机对照试验发现，中等强度运动干预 12 周后，患者体内 IL-6、TNF-α 等炎性因子水平显著降低，且这种抗炎效果在运动停止后的一段时间内仍能维持，说明其对炎症代谢通路产生了较为持久的重塑作用。然而，运动训练后长期全身炎症是否会减少尚无定论，需进一步研究[21]-[23]。

5. 低、中强度运动对 MHD 患者营养情况的影响

5.1. MHD 患者与营养不良状态

营养状况不佳和蛋白质能量消耗在 MHD 患者中很常见，并与不良结局相关。Seiji Kishi 等人[24]-[26]提出，营养和运动疗法是老年 CKD 患者的基本非药物治疗方法，这些疗法不仅可以增强药物治疗的效果，还可以帮助维持认知功能和生活质量。MHD 患者的营养问题是一个值得长期关注的问题，且可能与炎症因素相关。微炎症因子通过影响患者食欲、抑制胃酸分泌以及增加蛋白质分解，导致 MHD 患者营养不良[25]。Haiying Liu 等人[26]通过一项临床随机对照试验发现，透析中运动可改善 MHD 患者的血红蛋白、白蛋白(Alb)、肺功能、有氧能力和运动耐力，从而提高生活质量。

5.2. 低强度运动对营养的影响

从营养角度，低强度运动可以刺激患者胃肠蠕动，增强消化功能，一定程度上改善食欲。患者在规律

进行低强度运动一段时间后，主观反馈食物摄入量有所增加，且通过定期监测营养指标发现，血清前白蛋白水平趋于稳定甚至小幅度上升，反映机体蛋白质合成代谢得到一定促进，有助于对抗营养不良[25]-[27]。

5.3. 中强度运动对营养的影响

在营养改善层面，中等强度运动能更大程度地增加肌肉质量与力量。慢性肾脏病临床实践指南建议MHD 患者进行适宜中等强度的有氧运动(50%~70%峰值摄氧量、60%~70%最大心率或 RPE 评分为 11~13 分) [28]。以有氧代谢为主的运动在透析过程中能够将机体内代谢产物从透析液中排出，增加透析溶质清除量，提高透析效果，并减少体内氧化应激终产物的产生[29]。Dickinson JM 等人[30]-[33]通过一项临床随机对照试验发现，在必需氨基酸的充分补充下，随着运动强度提升，机体对能量与蛋白质需求增加，刺激肌肉蛋白合成信号通路激活，患者不仅四肢肌肉围度增长，肌肉力量测试评分提高，血清白蛋白等关键营养指标也明显改善，有效扭转营养不良态势。低至中强度的运动对 MHD 患者的长期收益是可观且有实施价值的[29]。

6. 低、中强度运动对 MHD 患者心脑血管事件的影响

6.1. MHD 患者心脑血管事件的发生情况

MHD 患者发生心脑血管并发症的风险较高，心血管不良事件包括心衰、心绞痛、心梗、伴有明显症状的心律失常，脑血管不良事件包括短暂性脑缺血发作、脑出血、脑梗死等，且相较于年轻患者，老年患者的致死致残率更高，是导致 MHD 患者死亡的主要原因[34] [35]。MHD 患者往往因基础情况较差以及在透析时多存在血压波动过大、凝血功能障碍、代谢紊乱等问题，使其发生心脑血管事件等并发症的风险是普通人群的 6~10 倍[36]-[38]。Xing Zhang 等人[39]纳入 156 名 MHD 患者，将其分为发生心脑不良事件组与未发生组，其发现 MHD 患者的尿毒症和高血压患者不良心脑血管事件的发生率与糖尿病、体质量增长率、血清甘油三酯等多指标相关，而运动可能对该系列指标带来显著改善[40] [41]。

6.2. 低强度运动对心脑血管事件的影响

低强度运动对心血管系统负担较小，却能助力患者逐步提升心血管功能储备。Marinei L. Pedralli 等人[42]-[44]通过一项随机临床试验发现，长期坚持低强度运动，可辅助降低血压，改善血管内皮功能，减少血液黏稠度，进而降低心脑血管事件发生的急性风险。一项基于社区的队列研究显示，MHD 患者坚持每周至少 3 次、每次 30 分钟的低强度步行运动，1 年内发生心脑血管意外事件的概率显著降低[12]。

6.3. 中强度运动对心脑血管事件的影响

中等强度运动可促使心脏每搏输出量增加、血管弹性增强，通过提升心肺功能，全方位降低心脑血管疾病风险因素[45] [46]。甲状旁腺素、血钙以及血脂在 MHD 患者冠脉钙化发展中起重要作用[47]。Haitao Zhang 等人通过一项多中心的前瞻性队列研究对 1489 名患者进行为期四年的随访评估，发现接受透析的患者冠脉血管钙化进展迅速，不同的血管钙化类型与冠脉钙化位置及进展率相关。长期规律中等强度运动可使 MHD 患者的血脂谱优化，高密度脂蛋白胆固醇升高、低密度脂蛋白胆固醇降低，同时降低血液同型半胱氨酸水平，减少动脉粥样硬化形成风险，显著减少冠心病、脑卒中等心脑血管事件发生率，提高患者长期生存率[48] [49]。但也有学者通过 META 分析发现，由于证据质量极低，尚不确定运动训练是否能改善成人 MHD 患者的死亡、心血管事件，运动干预对 MHD 患者心血管事件的影响有待进一步挖掘[50]。

7. 高强度运动在 MHD 患者中的可行性与影响探讨

高强度运动，如高强度间歇训练(high intensity interval training, HIIT)，是一种将高强度的运动时段与

低强度的恢复期交替进行的运动方式。HIIT 在普通人群健身中应用广泛，但对于 MHD 患者，由于患者身体机能受限，高强度运动可能瞬间加重心脏负担，引发心律失常、血压急剧波动等急性心血管不良事件，还可能导致肌肉损伤、横纹肌溶解等风险增加；另一方面，过度的动应激可能刺激机体炎症反应反弹，抵消运动带来的益处，其可行性仍存在争议。近年来，HIIT 的安全性及有效性逐步在非透析的 CKD 患者中得到证实[51]。有研究表明[52]，有监督的透析中高强度间歇训练(HIIT)在药物稳定的终末期肾病患者中安全可行。Birgitta 等人[52]对 20 名 MHD 患者分别进行为期 16~22 周的 HIIT、中等强度持续训练(Moderate intensity continuous training, MICT)及常规治疗，结果表明，HIIT 可导致患者心肺耐力和生活质量的显著提高。徐秀秀等人[53]对 160 例患者分别进行 12 周的 HIIT 和 MICT 训练，表明 HIIT 对患者透析中低血压、营养状态及生命质量的改善优于 MICT。综上，目前国内外研究样本量小、证据等级有限，HIIT 在 MHD 患者中的应用有待更深入探索，适合 MHD 的最佳运动强度有待进一步研究。

8. 结论

不同强度运动对 MHD 患者的炎症、营养及心脑血管事件具有显著影响。低强度和中强度运动均能有效改善 MHD 患者的炎症状态、营养状况及心脑血管健康，而高强度运动的可行性和安全性仍需进一步研究。未来的研究应进一步探讨不同强度运动对 MHD 患者的长期影响，以制定更为精准的运动处方。

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