Advances in Clinical Medicine 临床医学进展, 2025, 15(4), 765-772
Published Online April 2025 in Hans. https://www.hanspub.org/journal/acm
https://doi.org/10.12677/acm.2025.154993

前庭康复的治疗进展

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收稿日期：2025年3月3日；录用日期：2025年3月26日；发布日期：2025年4月7日

摘 要

前庭康复治疗是一项以运动为基础的治疗，大量的研究证据支持前庭康复治疗对眩晕患者有效。随着对眩晕疾病的深入研究，前庭康复治疗变得更多样、更高效。本文就前庭治疗的神经生理机制、前庭康复治疗技术进展以及眩晕患者的多因素管理等方面进行综述。

关键词

眩晕，前庭康复治疗，前庭代偿

Advances in the Treatment of Vestibular Rehabilitation

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Received: Mar. 3rd, 2025; accepted: Mar. 26th, 2025; published: Apr. 7th, 2025

Abstract

Vestibular rehabilitation is an exercise-based treatment, and many research evidence supports the effectiveness of vestibular rehabilitation in patients with vertigo. With the in-depth study of vertigo, vestibular rehabilitation has become more diverse and efficient. This article reviews the

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文章引用: 李甜甜, 王秀宇, 贾玉其, 屈永涛, 郭明丽. 前庭康复的治疗进展[J]. 临床医学进展, 2025, 15(4): 765-772.
DOI: 10.12677/acm.2025.154993

neurophysiological mechanism of vestibular therapy, the progress of vestibular rehabilitation techniques and the multifactor management of patients with vertigo.

Keywords

Vertigo, Vestibular Rehabilitation Therapy, Vestibular Compensation

1. 引言

眩晕(vertigo)是一种常见的临床综合征，表现为视物旋转、站立不稳及跌倒等症状，常合并恶心、呕吐、出冷汗等自主神经反应，不仅损害身体健康，还可诱发焦虑抑郁等情绪障碍。美国一项研究表明，眩晕和眩晕的发病率每年约 11%，其中中度至重度眩晕的终生患病率高达 30% [1]。随着生活和工作节奏加快，眩晕的发病率逐年增高，发病年龄逐渐降低[2]，引起的经济负担逐渐加重[3]。对于眩晕疾病的医学干预，除病因学治疗外，还应同时辅助前庭康复治疗。本文就前庭康复治疗的神经生理机制、前庭康复治疗的技术进展以及眩晕患者的多因素管理等方面进行综述。

2. 前庭康复治疗的神经生理机制

前庭疾病受损后的代偿、康复问题，目前主要来源于对急性单侧外周前庭病变的研究。临床将前庭代偿分为静态代偿和动态代偿两个阶段。单侧前庭损伤后，患侧部分前庭神经元静息活动丧失及对侧连合抑制的增强，导致两侧神经核之间神经活动失衡，诱导眩晕的发生。而这种失衡可通过“静态代偿”机制逐步缓解，患侧前庭神经元对 GABA 等抑制性神经递质的敏感性下降，降低了健侧对患侧的抑制效应[4]。前庭神经核神经元的突触具有双向可塑性，突触抑制或突触后超极化可以在前庭神经元中诱导内在兴奋性的长期增强[5] [6]。同侧神经元的抑制效应减弱与同侧前庭神经核神经元内在兴奋性增高相结合，两侧神经核神经活动达到放电再平衡。动态代偿机制主要包括修复、习服及适应。修复即在细胞及生化层面上损伤的神经突触恢复连接，依靠前庭神经系统的自我修复[7]。习服是反复暴露于引起头晕的特定刺激中，降低前庭中枢的敏感性。适应是一种强大的恢复机制，分为感觉替代与行为替代，神经中枢通过利用其他感觉线索或新制定的运动策略来替代受损的功能。前庭觉发生障碍时，机体上调视觉、本体觉的权重，小脑的预期感觉模型得到重建，弥补前庭觉的缺失[8]。行为替代是基于不同的大脑结构和神经元网络能够通过学习进行功能重组，模仿损伤的动态前庭功能，从而促进前庭代偿。大量数据表明主动的前庭康复训练能够有效促进前庭代偿的形成，减轻眩晕症状，并且越早训练越好[9]。

3. 前庭康复治疗技术进展

3.1. 经典前庭康复训练

经典前庭康复训练由 Cawthorne 和 Cooksey 在 20 世纪 40 年代提出[10] [11]，用于治疗战争中头部受伤后出现头痛、恶心以及平衡障碍的军人。Cawthorne-Cooksey 锻炼法采用分级的体育锻炼、心理锻炼和职业治疗。具体方法为：1、闭眼进行眼球及头部运动。2、肩关节环绕运动。3、爬楼梯训练。4、高低位抛球训练。Cawthorne-Cooksey 锻炼法能够促进前庭眼反射和前庭脊髓反射恢复，促进前庭代偿[12]。

3.2. 精准前庭康复训练

3.2.1. 凝视稳定训练

凝视稳定训练通过提高 VOR 增益或诱导代偿性扫视的变化来改善患者的动态视力(dynamic visual acuity, DVA) [13]，获得精准的视觉稳定性[14]。包括前庭眼反射(vestibular ocular reflex, VOR)适应性训练及 VOR 的替代性训练[15]。适应性训练即注视静止或运动的目标的同时保持头部运动，常使用的是 VOR1 和 VOR2。VOR1 练习，令患者眼睛注视正中位静止视靶，在水平或垂直方向上匀速移动头部。VOR2 练习，注视移动视靶，头部和目标水平或垂直方向上以相反的方向同时移动。替代性训练则 VOR 在补偿性扫视和眼球运动的中央预编程中得到替代[16]。如在主动的头部运动开始时产生的较大眼球扫视，可促进中枢预编程的使用，替代正常 VOR 缺失的慢相眼球运动。但扫视有效性的增高与视网膜滑动的幅度、频率以及头部运动的方向有着密切联系[17]。

3.2.2. 平衡及步态训练

急性前庭功能受损，神经中枢无法依靠视觉和本体觉输入的信息来维持平衡。随着代偿产生，视觉及本体觉所占权重增加，补偿缺失的前庭觉，增加姿势稳定性[18]。然而视觉和本体觉不能完全替代前庭觉，过度依赖视觉和本体觉会影响前庭代偿的恢复[19]。训练内容包括重心控制训练、多感觉训练及步态训练。重心训练涉及姿势的重心转移(如 romberg、单脚站立、交替)。多感觉训练则要求在改变视觉(睁眼/闭眼)和本体感觉(水平地面上/厚地毯上/泡沫垫上)情况下保持平衡。而步态练习除基础的脚跟脚尖直线行走外应加入动态条件，如行走时转头或行走时倒数。此外，对于老年人加强下肢肌肉强度，增加下肢肌肉力度，也是平衡及步态训练中的重要环节。Fatima 等证实了平衡练习可有效改善眩晕患者的平衡障碍和降低跌倒的风险[20]。

3.2.3. 习惯化训练

习惯化训练就是将机体反复暴露于引起眩晕的刺激中，如快速的视觉刺激、特定的体位刺激，系统性重复的刺激降低前庭的敏感性，进而减轻眩晕症状[21]。Brandt-Daroff 习服疗法最早于 1980 年提出，主要针对良性阵发性位置性眩晕(benign paroxysmal positional vertigo, BPPV)复位成功后出现的短暂的行走不稳、漂浮感或不典型眩晕等残余症状[22]。方法如下：① 坐在床边；② 右转头 45˚同时快速向左侧躺下，保持 30 秒；③ 坐起，保持 30 秒；④ 左转头 45˚同时快速向右侧躺下，保持 30 秒；⑤ 坐起。反复的体位变化可打散半规管中残余耳石促进内淋巴液吸收，此外反复的体位刺激使前庭中枢对半规管刺激的敏感性下降，从而促进前庭代偿，有效提高机体对平衡的协调能力和控制能力，减轻症状。

3.3. 前庭康复技术进展

3.3.1. 虚拟现实技术

虚拟现实技术(virtual reality, VR)利用计算机生成的动态三维空间的虚拟环境，参与者沉浸在逼真的、视觉上具有挑战性的环境中，通过自己的动作与虚拟环境相互动[23] [24]。操作者根据参与者情况通过操纵刺激参数(如速度、运动方向、刺激大小)给予不同等级的刺激强度[16]。运用虚拟技术为习惯化训练及平衡训练提供更精准的刺激信号及更复杂的训练环境。如平衡及步态训练时给予视动刺激。研究表明，VR 辅助前庭康复训练较传统康复训练的前庭眼反射增益、动态视力、姿势控制和平衡信息、VAS 评分都得到明显改善[25]。虚拟现实技术是一个有着潜在前途的新型康复训练方法，可有效减少康复训练的成本。但暴露在交互式的虚拟环境中，患者接受多感觉冲突的刺激，易出现恶心、呕吐等自主神经症状，这种身体变化往往会让患者产生担忧、恐惧[26]。

3.3.2. 人工前庭

人工前庭植入设想最初来源于 20 世纪 Cohen 和 Suzuki 发现电极刺激猴子壶腹神经可以引出眼球震颤[27]。随后单通道人工前庭假体模型机、多通道人工前庭假体、前庭耳蜗植入体也先后研发出来[28] [29]。人工前庭的设计思路主要有两种，一种为 Golub JS 团队设计的植入系统的传感器能感应头部 3D 运动信号，并能将运动信号转化为电信号刺激前庭神经[30]。另一种是 Nils Guinand 团队直接以稳态、恒定振幅的刺激持续刺激前庭神经，人为地恢复前庭传入神经地“自发”放电率[31]。但植入前庭植入物后会出现耳蜗损伤，仅适用于深度耳聋患者或反复发作的梅尼埃患者。Nils Guinand 对双侧前庭功能丧失患者耳朵植入了前庭植入物原型，即使用电极刺激壶腹部分支，所有患者均获得了静止状态下平稳、可控的眼球运动[32]、行走状态下的凝视稳定[28]，且高频 VOR 的恢复也得到了验证[33]。此外，Nils Guinand 进一步验证了前庭植入物也能有效改善双侧前庭功能丧失患者的姿势控制[34]。约翰霍普金斯医院对耳毒性药物导致的双侧前庭功能减退(bilateral vestibulopathy, BVP)患者植入前庭植入物，术后 6 个月受试者的生活质量、姿势、步态结果较基线均有所改变[28]。前庭植入物能重建前庭眼反射、恢复姿势稳定性，改善症状已经得到验证。但植入物电极的刺激参数、电极电流的扩散、植入物的位置以及对耳蜗的损伤都还需进一步研究[35] [36]。目前我国人工前庭技术研发还处于起步阶段，且距离临床应用很长的距离[37]。

3.3.3. 前庭电刺激

GVS 是一种用于刺激前庭系统的非侵入性方法，包括前庭传感器、神经通路、前庭核和接收集成前庭输入的皮质区域[38]。表面电极固定在乳突上并施加电刺激，一侧的前庭传入神经被激发(阴极)，另一侧被抑制(阳极)。这种刺激激活了大脑的前庭皮层，通过前庭输入调节运动反应的阈值或兴奋性。Serrador 等人揭示了通过 GVS 可增强前庭眼功能[39]，Nguyen 观察到以水平和扭转眼球震颤向阴极为特征的动眼神经运动[40]，刺激后姿势和眼球运动又会恢复到原来的位置。GVS 调节姿势和平衡，有效降低视觉剥夺下双侧前庭功能障碍(BVH)患者的步态偏差[41]。此外，GVS 不仅可以影响前庭功能，还可能影响空间记忆和感觉处理的更广泛的神经回路。研究发现 GVS 能有效改善前庭感知及空间定向能力[42]。Sabzevar 研究者发现，对大鼠进行前庭电刺激，在纹状体尾部发现电生理信号[43]。GVS 领域仍在不断发展，GVS 有着巨大的应用潜力，目前的研究验证了 GVS 的积极影响，但 GVS 的刺激频率、刺激强度及振幅在不同个体中仍需要进一步选择[44]。

4. 眩晕患者的多因素管理

临床研究发现，约 20%的眩晕患者合并高度的焦虑、抑郁情绪[45]。19 世纪有学者推测大脑中的前庭功能与情绪处理的神经网络组成成分有重叠[46]。研究证实前庭刺激可投射至边缘系统、脑回和臂旁核，通过小脑、脑干、间脑和杏仁核介导情绪反应[47]-[49]，引起神经肽、类固醇和单胺激素等化学物质产生[50]，对上述物质代谢能力低的患者就会出现焦虑、抑郁等情绪障碍。另外，情绪障碍产生的原因也与患者对疾病的认知缺陷有关。认知行为疗法(cognitive behavioral therapy, CBT)是一种心理治疗方法，通过改变错误的认知和消极的思维进而消除不良情绪，从而改善由此产生的功能障碍[51]。眩晕患者在药物和康复治疗基础上联合 CBT 进行干预，能控制焦虑、抑郁等情绪，从而更快改善眩晕症状，有效减少复发[52] [53]。因此针对心身疾病的药物治疗和认知行为治疗可酌情运用到眩晕疾病治疗中。

睡眠障碍也会影响前庭功能。前庭系统与睡眠中枢在结构上相互联系，大脑皮层、下丘脑、脑干等中枢结构既参与睡眠与觉醒周期，又参与前庭功能的调节[54]。睡眠相关的神经递质又与前庭系统有着密切联系，组胺有促觉醒作用[55]，能通过兴奋组胺受体 1 (H1)和组胺受体 2 (H2)介导前庭神经元去极化[56]，参与前庭代偿的产生[57]。对正常大鼠进行睡眠剥夺后观察到脑脊液中组胺浓度持续增加，但组胺

在两侧前庭神经核周围浓度不同，出现两侧前庭神经核放电不平衡，导致眩晕的发生[58]。食欲素是源于下丘脑外侧的一种神经递质，广泛分布于整个大脑，参与睡眠、觉醒、进食及奖赏过程。食欲素可通过激活食欲素 1 受体(OX1)和食欲素 2 受体(OX2)受体[59]，兴奋前庭神经核神经元，增强前庭神经元敏感性，调节姿势变化[60]。健康成年人连续睡眠剥夺后，脑脊液中食欲素水平高于正常，肌肉张力增加，导致控制平衡能力减弱[61]。临床研究发现，对正常人行 24 小时睡眠剥夺，双耳前庭肌源性诱发电位不对称率增高[62]，中枢神经对前庭驱动信号更加敏感[63]。综上，睡眠障碍可导致平衡障碍。

目前前庭康复治疗对眩晕症状和平衡功能的改善已得到公认，然而前庭康复治疗需要患者坚持训练、医师及康复人员个性化指导以及多学科参与和多因素管理才能取得良好的效果。

利益冲突

所有作者均声明不存在利益冲突。

基金项目

河北省政府资助临床医学优秀人才培养项目(ZF2024002)。

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