·综述·

全身振动防治骨质疏松的研究进展

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骨质疏松(osteoporosis, OP)的严重后果是发生脆性骨折,后者导致病残率及死亡率增加[1]。目前国内、外骨质疏松症诊疗指南均将康复治疗作为 OP 临床管理及脆性骨折预防中的重要组成部分[2-3]。针对 OP 的康复干预方式除负重运动及抗阻运动外,其他物理因子治疗也具有重要作用。物理因子干预为不便于进行大强度体力活动的老年人及其他因神经损伤或肌肉失用而无法进行高强度运动的继发性 OP 患者提供了治疗选择。全身振动(whole body vibration, WBV)作为一种无创、副反应小的物理因子干预方法,近年来被逐渐用于 OP 临床防治中。

振动的理念与实践源于二十世纪三十年代,最早发表在 JAMA 上的关于振动治疗心血管及周围血管疾患的研究开启了振动治疗疾病的先河[4]。随后振动治疗被应用于解决太空中失重引起的肌肉萎缩及骨钙流失,用于提高宇航员在太空中的骨密度及肌容量储备[5],增强运动员肌肉力量[6]。研究表明 WBV 作为一种无创性物理因子干预手段可引起肌肉及骨骼反应,为 OP 临床防治提供了新思路[7]。WBV 是利用振动平台将高频机械性振动载荷通过身体传导至骨骼、肌肉以及感受器,进而引起相应生理反应[8]。目前美国纽约州立大学、加拿大多伦多大学、德国埃尔朗根-纽伦堡大学、格廷根大学、荷兰鹿特丹大学以及中国香港理工大学等众多科研机构均在进行 WBV 防治 OP 的研究工作。本文拟通过系统检索涉及 WBV 对机体骨骼、肌肉、平衡、疼痛及骨代谢等方面影响的相关文献,从而探讨 WBV 在防治 OP 方面的作用效果及可能机制。

WBV 防治 OP 的研究回顾

一、WBV 对骨矿密度的影响

OP 患者的主要问题是骨强度下降,骨强度包括骨矿密度(bone mineral density, BMD)及骨质量,但由于临床缺乏测定骨质量的有效方法,导致 OP 的诊断及评估仍以 BMD 改变为标准[9]。BMD 提高可增强骨折负荷[10],如有研究报道,骨量增加 3% ~5%,将来发生骨折的风险可减少 20% ~30%[11];但 WBV 是否能够有效增加 OP 患者 BMD 目前仍存在争议。

Rubin 等[12]通过为期 1 年的前瞻性、随机、双盲研究(研究对象为 70 例绝经后女性)发现,短时间(20 min)、低振幅(0.2 g)、相对较高频率(30 Hz)的 WBV 治疗能使受试者椎体 BMD 较治疗前增加 0.18%,差异具有统计学意义($P=0.009$);股骨颈 BMD 较治疗前降低 0.13%,差异无统计学意义($P=0.19$);进一步分析发现,WBV 对具有高治疗依从性的低体重(<65 kg)研究对象其腰椎 BMD 的改善作用尤为显著。Iwamoto 等[13]研究结果也证实 WBV 干预能增强腰椎 BMD($P<0.05$),但对髋部 BMD 无明显影响作用($P>0.05$)。

Verschueren 等[14]研究发现,与抗阻训练组比较,WBV 治疗组患者经 6 个月治疗后,其髋部 BMD 较抗阻训练组增加了 1.51%($P<0.05$),较空白对照组增加了 1.53%($P<0.01$)。Gusi 等[15]研究证实,WBV 治疗组股骨颈 BMD 较步行训练组增加了 4.3%($P=0.011$),但 2 组患者治疗前、后腰椎 BMD 均无显著变化。

一项针对 202 例绝经后女性对象的随机对照研究(持续 12 个月)显示,治疗组经每天 20 min、90 Hz 或 30 Hz WBV 干预后,其骨(包括股骨颈、髋、腰椎等)检测结果与基线水平及对照组间差异均无统计学意义($P>0.05$)[16]。Verschueren 等[17]研究结果也表明,WBV 治疗组髋 BMD 与对照组间差异无统计学意义($P>0.05$)。Alba 等[18]对 49 例老年人的研究结果也证实,40 Hz、每周 3 次、每次 10 min、共持续 11 周的 WBV 干预对受试者髋部及腰椎 BMD 并无显著影响作用。

由于上述各文献中的振动方案设计、振动参数及结局测量指标异质性较高,这在很大程度上影响了 WBV 对 BMD 的疗效,且 BMD 的提高往往需要基础干预(如钙及维生素 D 补充)及其他干预(如抗骨质疏松药物、运动疗法及 WBV 等)共同作用,上述研究中绝大部分受试对象并没有补充钙与维生素 D,这在很大程度上影响了试验结果。故关于 WBV 是否能够提高机体 BMD 水平,还需要更多高质量的临床随机对照研究证实。

二、WBV 对肌力的影响

相关研究表明,肌力改善可提高骨折负荷,进而降低骨折发生率[10]。Stengel 等[19]在传统运动训练中增加 WBV 治疗,发现与单纯运动组比较,振动加运动组其下肢伸膝肌力及躯干屈曲肌力均显著增加,组间差异均具有统计学意义($P<0.05$)。Mikhael 等[20]通过随机对照试验观察不同站姿下老年人上、下肢肌力改变情况,发现经 3 个月振动治疗后,振动组在膝关节放松站姿及膝关节伸直姿势下其上、下肢肌力均较对照组明显提高,组间差异均具有统计学意义($P<0.05$)。Kennis 等[21]还观察了 WBV 对肌肉功能的残留效应,通过对 72 例老年对象给予每周 3 次、为期 1 年的 WBV 干预,于治疗结束 1 年后随访发现,老年对象经 WBV 干预后增加的肌容积又恢复至基线水平,而抗阻+有氧运动组其等长肌力仍在持续增加,WBV 治疗组未发现类似结果,可能原因是由于抗阻+有氧运动组的运动负荷大于 WBV 治疗组,前者能激活更多运动单元。上述结果提示,临床在制订运动处方时,不仅要考虑该运动在治疗结束时能起到的作用,还应关注该运动带给患者的长期效应。

Osawa 等[22]的 Meta 分析使用关键词"vibration"、"exercise"、"training"、"performance"、"strength"、"power"、"fitness"筛选了 WBV 干预时间大于 5 周的随机对照临床研究,分析后发现 WBV+运动疗法或单纯 WBV 干预均能提高受试者伸膝肌力及向后跳跃能力,提示 WBV 对肌力的影响与抗阻运动疗效类

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似。但由于 WBV 操作简单、运动强度小,能为不便于进行大强度体力活动的老年人或因神经损伤、肌肉失用而无法进行高强度运动的继发性 OP 患者提供治疗选择。

三、WBV 对机体平衡、移动能力及跌倒的影响

Bautmans 等[23]通过对 24 例疗养院老年人进行 WBV 治疗,发现治疗后入选对象起立到行走时间、Tinetti 测试评分(包括身体平衡和总分)明显改善。Gusi 等[15,24-27]研究发现 WBV 治疗组平衡功能、移动功能均较步行训练组明显提高。von Stengel 等[28]还发现 WBV 治疗能减少绝经后女性对象的跌倒次数($P<0.05$)。相关的系统评价充分说明了 WBV 可提高研究对象动态平衡能力及移动功能,但对跌倒的影响作用仍未确定[29-30]。

四、WBV 对骨代谢标志物的影响

目前关于 WBV 对骨代谢标志物影响的研究较少,可能是由于大部分研究者认为 BMD 的随访结果能间接反映患者体内骨代谢水平;但骨代谢标志物水平的高低是反映 OP 病理过程的重要指标。悉尼大学 Sarah 等[31]对 46 例绝经后女性 OP 对象研究后发现,持续 8 周、每周 3 次的 WBV(12 Hz,0.3 g)治疗能降低骨吸收标志物-尿Ⅰ型胶原氨基末端肽/肌酐(N-telopeptide X/creatinine,NTx/Cr)含量,但对骨形成标志物-骨特异性碱性磷酸酶(bone specific alkaline phosphatase,BALP)的影响作用不显著。Zheng 等[27]发现持续 6 个月的 WBV 治疗能降低老年人血液中骨钙素及抗酒石酸酸性磷酸酶-5b 含量,由此推测 WBV 能抑制骨转换,进而减少骨量丢失。Iwamoto 等[13]发现绝经后女性 OP 患者经 WBV 治疗后,其尿Ⅰ型胶原氨基末端肽(N-terminal crosslinking telopeptide,NTx)、血清碱性磷酸酶(alkaline phosphatase,ALP)水平均较基线时有所降低,但与单纯使用双膦酸盐类口服药物组比较,发现组间差异无统计学意义($P>0.05$)。这可能是由于阿仑膦酸盐对骨代谢有较强作用,组间差异无统计学意义可能是由于"天花板效应"造成。另外也有研究报道,与对照组比较,WBV 治疗组骨钙素有所提高,Ⅰ型胶原羧基末端肽(C-terminal crosslinking telopeptide,CTX)则明显降低,但 WBV 治疗组上述指标与抗阻运动组间差异均无统计学意义($P>0.05$),提示 WBV 治疗对骨代谢的影响作用与抗阻运动疗效相当[32]。另有文献报道,年轻(19~38 岁)受试者经 WBV 治疗后,其骨代谢标志物(如骨钙素、抗酒石酸酸性磷酸酶等)无明显变化($P>0.05$),作者分析认为该研究对象本身日常活动能力较好,其骨骼处于良好状态,故 WBV 对这一类人的影响作用不显著[33]。

五、WBV 对骨质疏松性疼痛的影响

由于疼痛的复杂性及测量时个体差异较大,目前鲜见有涉及 WBV 对骨质疏松性疼痛影响的报道。Kosar 等[34]在 2012 年发表了一篇关于 WBV 对运动后肌肉恢复影响的简评,其中提到 WBV 干预可减少剧烈运动后肌肉疼痛,加快肌肉功能恢复,减轻由于运动带来的肌腱损伤。一项针对 50 例绝经后女性 OP 对象的研究结果显示,阿仑膦酸盐组和 WBV + 阿仑膦酸盐组分别经相应治疗后,发现表情疼痛量表分值组间差异具有统计学意义($P<0.05$),提示 WBV + 阿仑膦酸盐治疗可有效缓解疼痛[13]。上述研究结果表明,WBV 干预对肌肉疼痛具有缓解作用,但有关 WBV 对骨质疏松性疼痛的确切作用机制还有待进一步探讨。

WBV 治疗 OP 的可能机制

关于 WBV 治疗 OP 的可能机制主要包括以下方面:①增加静脉压及增强骨组织灌注,有助于提高骨量[35],WBV 可改善绝经后女性下肢血液循环[36],还可刺激骨折愈合时血管生成[37],提示刺激血管生成、增加骨灌注量可能是 WBV 影响骨量的重要途径之一。②改变Ⅱ型肌纤维数量及活性。Robert 等[38]研究结果显示,随着年龄增长,机体Ⅱ型肌纤维会逐渐萎缩且数量减少,而 WBV 产生的振动可补偿由于肌肉萎缩而减弱的机械刺激。③基质流变学说。WBV 能刺激成骨细胞及破骨细胞迁移并修复微损伤部位[39]。成骨细胞、破骨细胞、骨基质细胞在微管中流动时可受 WBV 产生的应变效应影响,通过不同机制增加骨基质含量,如骨原始细胞在 WBV 刺激下能增殖、分化为生成骨基质的成骨细胞[40]。

WBV 治疗参数的设置

在临床治疗时 WBV 振动频率多集中在 30~50 Hz 或 90 Hz,加速度为 0.15~3.00 g(g = 9.8 m/s2),治疗时可供选择的振动方案差异较大,如 10 min/d×5 d/w×4 w[41]、30 min/d×5 d/w×12 w 等均为常见治疗方案[42]。Judex 等[41]研究显示,90 Hz WBV 治疗具有较强的成骨作用,而 45 Hz WBV 治疗对受试者骨形态学方面无明显影响作用,推荐采用较高频率 WBV 进行治疗,但高频率 WBV 治疗时患者舒适度急剧下降,其治疗依从性亦较差。在振动方案选择方面,有研究显示间歇振动疗效优于持续振动,在振动治疗过程中设置一定的休息时间,可防止机体对振动产生适应性,从而保证疗效[43-44]。目前临床用于改善人体 BMD 的 WBV 治疗参数推荐为 30~50 Hz、加速度<1 g、15~30 min/次、1 次/d、3 d/w、治疗周期≥3 个月[1],但最佳振动治疗方案仍有待进一步研究探索。

WBV 治疗时的不良反应

目前还鲜见关于 WBV 治疗后发生严重不良反应的报道,少数人经 WBV 治疗后有腰痛[45]、耳鸣、下肢麻刺感、膀胱不适感等异常[16],但均为暂时性症状,随后自然恢复,上述不良反应是否与 WBV 治疗有关还有待考证。日本 2013 年有文献指出,低加速度的 WBV 治疗与腰痛无关[46]。总的来讲,只要避开人体的共振频率,WBV 则是一种安全、有效的非药物治疗手段。

结语

目前临床越来越重视如何防治 OP 患者脆性骨折及其他不良后果,而不是单纯治疗低 BMD;并且越来越多的证据表明,非骨骼因素(如肌肉性能、平衡功能等)是老年 OP 人群骨折的决定因素。关于 WBV 对 BMD 的治疗疗效目前尚无定论,但现有研究表明 WBV 对机体平衡功能、肌力及移动能力等均具有正面影响,可减少跌倒及发生 OP 性骨折的风险。总之 WBV 治疗因其无创、简单、方便易行等优点而倍受临床关注,其对 OP 的影响及确切作用机制还有待进一步探讨。

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Mulligan's taping for ankle instability

BACKGROUND AND OBJECTIVE After ankle sprain, patients may experience re-sprain and the potential for subsequent development of chronic ankle instability. One of the most popular methods of supporting the ankle after ankle sprain is taping, both to prevent further sprains by external support and to enhance proprioceptive activity. This study examined whether fibula repositioning taping (Mulligan's taping) affects postural control in professional athletes with chronic ankle instability.

METHODS Participants were 16 professional athletes with chronic ankle instability and 16 matched athletes without ankle instability. The subjects were screened using two questionnaires adapted from the Foot and Ankle Disability Index and the Foot and Ankle Disability Index-Sports. All participants performed a postural control test with and without taping. Pre- and post-taping, both groups performed the star excursion balance test, which incorporates single-leg stance on one leg with maximal reach of the opposite leg. The chronic ankle instability group performed the star excursion balance test standing on the injured leg.

RESULTS Before taping, greater reaching distance was found in all directions for healthy athletes than for those with chronic ankle instability. After taping, there was a significant increase in reaching distance for the medial, anteromedial, posteromedial, and overall reach. Such significant improvements were also found in the healthy athletes, with the exception of the anteromedial direction.

CONCLUSION This study found that Mulligan's Fibula Repositioning Taping can significantly improve postural control of athletes with chronic ankle instability. Improvements were also noted in healthy controls.

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