·综述·

接触阳光与儿童近视关联的研究进展

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【摘要】 近视已成为影响儿童健康最重要的问题之一。日益增多的研究表明，减少接触阳光时间可能是儿童近视发生发展的一个潜在诱因，而走向户外、亲近阳光可能是预防近视最经济有效的手段。本文就接触阳光与儿童近视关联的研究进展及其作用机制进行综述，为儿童近视防控提供新线索。

【关键词】 近视；儿童；维生素D；多巴胺；紫外线

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Progress in research of association between myopia and sunlight exposure in children *Zhai Lulu, Wu Xiaoyan, Xu Shaojun, Tao Fangbiao*

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【Abstract】 Myopia has become a major health problem on global scale due to its increasing high prevalence in the past few decades and gradual younger onset age. Accumulated epidemiological surveys have shown that decreased time of exposure to sunlight would be an inducement for the development of myopia. Increasing time spent outdoors and exposure to sunlight might be the most cost-effective and effective measure for children to prevent myopia. This paper summarizes the progress in research of the association between sunlight exposure and myopia in children and its mechanisms to provide new clues for the research on myopia prevention and control.

【Key words】 Myopia; Child; Vitamin D; Dopamine; Ultraviolet rays

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近视作为屈光不正中发病率最高的疾病，近年已成为全球性公共卫生问题[1]。其中以东亚地区学生近视患病率攀升尤著，高中毕业生近视患病率已高达80%～90%[2]。我国自1985年以来历次全国学生体质健康调查结果显示，中小学生视力不良和疑似近视检出率持续上升，并出现低龄化倾向[3]。然而，目前近视尚无有效的治疗方法，通过佩戴矫正镜和低剂量阿托品等治疗效果有限[4]。近视的确切病因至今仍不明确，但日益增多的研究证据表明，户外活动时间对儿童视力的健康发育至关重要，其对儿童近视的保护作用可能与阳光接触有关[5]。

1. 户外活动与儿童近视可能存在关联：东亚地区学生近视患病率居高不下的原因可能与该地区的高度城市化、教育压力过大，以及生活方式的改变导致儿童户外活动时间减少有关[6]。

（1）横断面研究：越来越多的研究发现，户外活动时间与儿童近视呈负相关[7-8]，如新加坡的近视危险因素研究中，在控制年龄、性别、种族、父母近视情况等混杂因素后，每天户外活动时间与近视存在关联（OR=0.90，95%CI：0.84～0.96），提示户外活动时间越长的儿童近视患病率越低[9]。Rose等[10]对新加坡与澳大利亚悉尼的华裔儿童近视患病率比较研究，尽管两组儿童可能表现出相似的近视遗传特质，但后者近视患病率仅为3.3%，而前者则为29.1%，进一步分析儿童生活方式发现，新加坡儿童户外活动时间（3.05 h/w）远低于悉尼儿童（13.75 h/w）。对北京市城乡学生视力研究也发现，近视儿童户外活动时间明显低于非近视儿童[11]。Sherwin等[12]对最近20年关于户外活动时间与儿童青少年近视相关的文献进行Meta分析结果表明，每周户外活动时间每增加1 h，近视发生的风险可降低1.9%（OR=0.981，95%CI：0.973～0.990，P<0.001）。

（2）纵向研究：美国种族与屈光不正合作队列评估研究中，将6～14岁731名近视与587名正视儿童对比，发现近视组儿童户外活动时间无论在近视前或近视后始终低于正视组儿童，进而猜测较少的户外活动时间是近视的危险因素[13]。悉尼近视研究的随访结果显示，儿童近视发病率随着

户外活动时间的增加呈下降趋势[14]。Jones等[15]在奥林达队列研究中发现，充足的户外活动时间能降低父母近视对儿童近视带来的危险度。中国安阳儿童眼病研究为期2年的随访结果显示，户外活动时间对基线时非近视儿童的眼轴伸长有保护作用（β＝−0.036，95% *CI*：−0.063～−0.009，*P*＝0.009），但与基线时已发生近视儿童眼轴伸长的关联无统计学意义（β＝−0.005，95%*CI*：−0.024～0.014，*P*＝0.595）[16]。另外土耳其的一项研究表明在7岁前的户外活动对儿童近视的发生发展具有保护作用（*OR*＝0.44，95%*CI*：0.23～0.82，*P*＝0.01）[17]。

（3）干预研究：中国广州队列对6所中小学校开展了持续3年每个学习日增加40 min户外活动的干预研究，结果显示干预组学生近视累积发生率为30.4%，对照组为39.5%，干预组与对照组3年等效球镜度变化差异有统计学意义（−1.42 D *vs.* −1.59 D，*P*＝0.04）[18]。本课题组前期在沈阳市开展的干预实验显示，学生学习日上下午各增加30 min户外活动时间，12个月后干预组学生平均视力（4.85±0.24），明显优于对照组（4.81±0.27），差异有统计学意义（*t*＝12.50，*P*＜0.01）[19]。易军晖和李蓉蓉[20]对80名7～11岁近视儿童进行2年干预研究发现，增加户外活动时间可减慢儿童近视的进展。Wu等[21]对台湾地区在校儿童的干预结果也表明，增加户外活动时间对儿童近视的发生发展具有保护作用。

综上所述，户外活动时间可能在减缓儿童近视发生和发展中起重要作用，但也有研究并未发现两者之间存在关联。北京近视发展研究对中小学生调查结果显示，小学生的户外活动时间与其近视程度存在关联，但与中学生的近视程度关联无统计学意义[22]。Zhang等[23]对户外活动时间与近视发展之间关联进行单因素和多因素分析，均无统计学意义（*P*＝0.49，*P*＝0.61）。Jones-Jordan等[24]对近视患者研究表明，户外活动时间并不能减缓近视发展。这可能与研究对象的年龄阶段及户外活动时间评价方法差异有关，提示户外活动对儿童近视的保护作用可能存在关键时期，且户外活动时间可能需要达到一定的阈值才能减缓近视的发生和发展。

2. 接触阳光对儿童近视可能具有保护作用：Guggenheim等[25]研究发现，儿童近视的发生发展与户外活动时间有关，而与体力活动强度无关。Rose等[26]对悉尼51所学校儿童近视患病率和危险因素的调查表明，户外活动可减缓儿童近视发展，而室内活动与近视的关联无统计学意义（*P*＝0.9）。因此，户外活动对儿童近视的保护作用是“户外”而不是“活动”本身[27]。

与室内活动相比，户外活动可接触更高水平的阳光。Donovan等[28]研究发现，近视的发展具有季节波动性，夏季近视发展比冬季缓慢，提示近视发展可能与阳光接触有关。也有研究表明较多使用自然光可减缓近视发展[20]。近年来研究者开始关注阳光接触与近视的关系，并发现多接触阳光为视力保护因素[29]。Read等[30]对101名儿童体力活动及户外接触阳光的监测结果显示，近视组儿童与正视组儿童每天体力活动水平差异无统计学意义，但近视组儿童每天可见光暴露量（915±519）勒克斯（lx）明显低于正视组儿童（1 272±625）lx，差异有统计学意义（*P*＜0.01），且近视组儿童每天户外强光暴露（＞1 000 lx）时间（127±51）min明显低于正视组儿童（91±44）min，差异有统计学意义（*P*＜0.001）。McKnight等[31]通过检测结膜紫外线自发荧光（conjunctival ultraviolet autofluorescence，CUVAF）客观评定儿童阳光接触水平以研究紫外线与近视关联，结果表明近视组儿童CUVAF中位数（31.9 mm^2）低于非近视组（47.9 mm^2），两组差异有统计学意义（*P*＜0.001）。Sherwin等[32]也使用检测CUVAF方法，结果近视者CUVAF（16.6 mm^2）低于非近视者（28.6 mm^2）差异有统计学意义（*P*＝0.001）。CUVAF是近期户外阳光接触的生物标志物，随着CUVAF总量增加，近视患病率降低，表明近视者与非近视者的户外阳光接触水平具有差异。

丹麦的一项研究也发现，随着日照时间的增长，儿童的眼轴生长和近视发展呈下降趋势[33]。基于阳光接触对近视保护作用的动物实验研究也表明，户外阳光接触可降低恒河猴近视发生的风险，且生命早期的阳光接触有助于视觉正视化发展[34]。

3. 接触阳光对近视保护作用的可能机制：

（1）高照度环境：室内外光照度差异很大，户外阳光充足环境中光照度可达数千甚至10万至20万lx，而室内光照度通常低于数百至1 000 lx[35]。户外的高照度环境可刺激瞳孔缩小增加景深进而减缓近视的发生发展，符合离焦假说[36-37]。

本课题组前期在沈阳市开展改造教室灯光干预实验，12个月后实验组与对照组学生裸眼视力差异有统计学意义，其中小学生实验组与对照组（4.90±0.20）*vs.*（4.87±0.21），*F*＝13.61，*P*＜0.001；初中生实验组与对照组（4.73±0.28）*vs.*（4.68±0.32），*F*＝14.25，*P*＜0.001，表明改善教室光照环境有利于减缓学生视力下降速度[38]。Ashby等[39]实验表明，暴露在强光环境下（不管是阳光还是实验室光源）的仔鸡，均可减缓近视进展。对猴进行的形觉剥脱性近视试验研究表明，高照度环境可减缓其形觉剥夺性近视发展[40]。

（2）光-多巴胺假说：多巴胺作为视网膜上一种重要的神经递质在近视的发生发展过程中起重要作用[41]，其受光刺激上调特性也是视网膜时钟网络的重要组成部分[42]。形觉剥脱性近视实验表明，光照可刺激视网膜多巴胺释放，进而阻止眼球伸长，而眼轴增长是近视发展的主要机制[43-44]。Cohen等[45]对仔鸡的实验结果表明，视网膜多巴胺释放速度与光照度近似呈对数线性增加，光-暗周期下饲养的仔鸡其视网膜多巴胺释放速度及屈光发展由外周环境光照度决定。

大部分视网膜多巴胺含量研究都是基于形觉剥脱性近视和负镜诱导性近视形成后测得，无法准确反映多巴胺在近视过程中的变化，目前亟需特异性作用于视网膜的新药物或特异性改变视网膜多巴胺含量的新技术，才能更有力地说明视网膜多巴胺的含量在眼球的生长和屈光发育中的作用[41]。

（3）光源波谱假说：Mehdizadeh和Nowroozzadeh[46]认为，户外活动对近视的保护作用是由于光源波谱组成差异而非光照度的差异，室内光源大多是长波长光，其光束多聚焦

在视网膜后方，这会促进眼球增长继而形成近视；而户外接触的阳光主要是短波长光（蓝光），当眼睛暴露在光度、对比度缓慢变化的环境中，短波长光可阻止近视发展[47]。过去许多研究都认为蓝光对眼睛存在危害，但近年来日益增多的研究表明蓝光对屈光发育有利[48]。动物实验将豚鼠[49]及恒河猴[50]饲养在不同波长的光环境中发现，长波光组动物多发展为相对近视，而短波组更易发展为相对远视。Chu等[51]对视网膜色素上皮细胞进行培养发现，蓝光可能通过减少肝细胞生长因子的表达抑制近视进展[52]。但Smith等[53]用恒河猴婴猴的试验研究没有发现证据表明长波长光一定会促进近视形成。

（4）维生素D假说：人体内90%以上维生素D来自皮肤内源性合成的维生素D_3，通过膳食摄取的维生素D不足10%，较多户外活动提供充分日晒可提高体内维生素D水平[54]。研究发现，在校正年龄和饮食等混杂因素后，近视组外周血维生素D平均值13.5 ng/ml低于非近视组16.9 ng/ml[55]。澳大利亚雷恩队列研究结果显示，血清维生素D水平<50 nmol/L组较≥50 nmol/L组近视的*OR*值为2.63（95%*CI*：1.71～4.05）[56]。

一项病例对照研究表明，近视组儿童血清维生素D浓度为（22.25±9.08）ng/ml，对照组儿童为（27.67±8.33）ng/ml，差异有统计学意义（t=2.281，P=0.031），且近视组儿童的血清维生素D水平与户外活动时间呈正相关（r=0.453，P=0.014），与眼轴呈负相关（r=−0.555，P=0.002）[57]。Choi等[58]对韩国青少年研究发现，近视患病率与低血清维生素D浓度有关，这种关系在高度近视青少年中尤为明显。荷兰一项对6岁儿童的研究，调整协变量后血清维生素D浓度与眼轴长度呈负相关（β=−0.043，P<0.01），低血清维生素D浓度儿童患近视的风险更高[59]。Mutti等[60]研究表明，近视与维生素D受体基因多态性呈低到中度关联。但英国Avon亲子纵向研究显示，维生素D和D_3的水平与儿童户外时间呈正相关，但与近视之间的关联无统计学意义[61]。

4. 阳光接触的评价方法：阳光接触的评价方法目前尚无统一标准，选择适当的测量方法是研究设计中的重要部分，要考虑到对研究的实用性、适用性、成本等问题，不适当的方法会导致测量结果存在偏差以及错误的描述疾病与暴露之间关联[62]。

（1）估算：大部分流行病学研究通过问卷自我报告数据对受试者进行回顾性调查，问卷内容包括户外活动时间、防晒措施、晒伤经历等[63-65]。还有一些研究使用日记法进行阳光接触指数评价，根据受试者外出着装习惯进行等级评分或按照外科烧伤九分法计算肢体暴露程度，与户外活动时间乘积后估算出个体阳光接触水平[66-67]。日记法相对问卷较准确，但同属回顾性调查，易出现偏倚，与个体紫外线暴露剂量测量方法的相关性较差[68-70]。

有研究采用地理信息系统中当地紫外线环境数据，进而估算出个体阳光接触水平[71]。但Sun等[72]研究表明，用环境紫外线水平估算个体紫外线水平存在较大误差。

（2）量化：常见测量紫外线累积量的方法有聚砜薄膜法和生物膜测定法，分别使用光敏化学材料和对紫外线敏感的微生物作为薄膜，为避免饱和需每天更换薄膜[73-74]。目前电子紫外线测定仪日渐兴起，其根据电池续航能力不同可连续使用数天，数周甚至数月，实现了长时间实时测量个体紫外线暴露，测量频率仅数秒[75-76]。也有研究把估算和量化的方法联合使用[77]。值得关注的是，无论选择何种设备都需要考虑其佩戴位置。Weihs等[78]研究发现，测定仪佩戴在身体不同部位以及不同活动方式中所测得数据有所差异。目前研究多佩戴在腕部、左臂上方、头顶或额头，可根据研究需要选择最佳位置进行准确测量。如何准确量化阳光接触是一项具有挑战性的工作，未来研究应设计可靠的量化方法，选择适当的测量仪器为近视与阳光接触关联研究提供可靠证据。

综上所述，儿童近视的发生发展可能与缺乏阳光接触有关。走到户外，亲近阳光可能是预防儿童近视发生发展最经济和最有效的手段[27]。但目前阳光接触在儿童近视发生发展中的作用及其风险预测还没有专题研究，需要探索研制我国儿童适用的阳光接触性户外活动模式评价方法，并建立前瞻性队列随访阳光接触与儿童近视发生发展的因果关联，为儿童近视防控提供循证决策依据。

利益冲突 无

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