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· 综　述 ·

儿童青少年屈光筛查方法的研究进展

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【摘要】 近视为屈光不正中最为常见的类型, 近年来, 近视发病逐渐呈现低龄化趋势, 对儿童青少年进行视力筛查及近视预防具有十分重要的意义。研究对睫状肌麻痹验光法、裸眼视力联合非睫状肌麻痹状态下综合验光, 眼轴长度与角膜曲率比值、Suresight 和 Spot 视力筛查仪等视力筛查方案的有效性及局限性进行综述, 为今后更好地筛选和改善中国儿童青少年视力健康水平提供科学依据。

【关键词】 屈光不正; 多相筛查; 儿童; 青少年

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Research progress on refractive screening methods for children and adolescents/*CHEN Qiwen, FANG Jing. Department of Ophthalmology, Children's Hospital of Chongqing Medical University/National Clinical Research Center for Child Health and Disorders/Ministry of Education Key Laboratory of Child Development and Disorders/Chongqing Key Laboratory of Pediatric Metabolism and Inflammatory Diseases, Chongqing* (400016), *China*

【**Abstract**】 Myopia is the most common type of refractive error. In recent years, the onset of myopia has shown a trend towards younger ages, making vision screening and myopia prevention among children and adolescents particularly significant. The study reviews the effectiveness and limitations of various vision screening protocols, including ciliary muscle paralysis optometry, combined uncorrected visual acuity and non-cycloplegic auto-refraction, axial length to corneal radius of curvature, as well as Suresight and Spot vision screening devices, to offer a scientific foundation for the future enhancement of vision health screening and improvement among Chinese children and adolescents.

【**Keywords**】 Refractive errors; Multiphasic screening; Child; Adolescent

随着电子产品的普及和生活方式的改变, 近视呈现出低龄化的态势, 2020 年中国 6~18 岁儿童青少年近视率高达 52.7%, 人数约达 1 亿, 若不加以干预, 至 2030 年我国儿童青少年近视率可达 61.8%[1-2]。近视防治工作逐渐成为社会普遍关注的问题, 而定期监测儿童屈光状态, 构建完善的个体化屈光档案是防控近视的关键[3]。笔者对多种常规视力筛查方案进行综述汇总, 比较其筛查近视的优劣性, 以期为不同年龄段儿童青少年屈光档案的建立及研究提供指导。

1　儿童正常的屈光状态发展规律

视觉发展是一个长期的过程。在婴幼儿期, 由于视轴尚未完全发育, 只有约 17 mm, 屈光状态表现为生理性远视。正常情况下, 3 岁前屈光度数为+3.00 D, 4~5 岁时为+1.50 D, 6~7 岁时为+1.00~+1.50 D[4]。随着年龄的增长, 角膜曲率逐渐变平, 眼轴变长, 儿童和青少年的远视度数逐渐降低, 通常在 15 岁时发展为正视眼(屈光度数为-0.50~+0.50 D)[5]。

2　视力筛查的重要性及分类

定期视力筛查是一种低成本、高回报的预防及治疗儿童屈光不正的手段。美国预防医学工作组指出, 支持多重筛查测试在识别有视力问题的学龄前儿童方面具有良好效用, 其对儿童定期进行视力筛查可以带来上亿美元的经济效益, 可见无论是从经济方面, 还是防控有效性方面, 都是一个很好的方案[6]。中华预防医学会公共卫生眼科分会专家共识指出, 远视储备不足的预防要求是对学龄前儿童视力展开动态监测, 建立个体化视力档案, 定期筛查, 以期能够早期发现儿童近视, 并制订针对性的干预措施[7]。如今针对不同年龄的视力筛查方法, 各自具有不同的特点及缺陷, 常见的视力筛查方案包括睫状肌麻痹验光法(金标准)、裸眼视力(uncorrected visual acuity, UCVA)联合非睫状肌麻痹状态下综合验光仪主觉验光(non-cycloplegic auto-refraction, NCAR)、轴率比、其他相关筛查方法。

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2.1 睫状肌麻痹验光法(金标准) 睫状肌麻痹验光法是目前国际通用的金标准。儿童睫状肌存在较强调节力,通过睫状肌麻痹剂散瞳后,能抵消眼部自身调节,从而测得准确的屈光度,明确判断患儿是否存在假性近视,以达到及早治疗、降低近视风险的目的。国内常用的睫状肌麻痹剂包括阿托品眼用凝胶和复方托吡卡胺滴眼液[8],阿托品作为目前睫状肌麻痹作用最强的药物,通过阻断 M 胆碱能受体,解除睫状肌痉挛,有效减少验光中自身调节的影响,但起效缓慢、持续 3~4 周,伴有畏光、视近模糊等副作用,影响屈光不正儿童的日常生活和学习。托吡卡胺起效快、持续时间短,但麻痹作用不完全,容易受到调节的影响,在临床的应用受到一定限制。国际上将环戊通滴眼液列为一线散瞳药,其是一种抗胆碱药,起效时间快、持续作用时间短[9]。国内外对于阿托品及环戊通疗效做过许多对比研究,认为两者睫状肌麻痹效果相似,环戊通可以替代阿托品成为临床快速验光首选药物[10-11]。睫状肌麻痹验光法因其能够消除睫状肌调节的影响,从而更准确地反映眼睛的真实屈光状态,特别适用于儿童验光、散光检查以及需要精确度数的情况。然而,该方法也存在一些不利因素:首先,麻痹药物可能导致眼睛干涩和光敏感等副作用。其次,睫状肌麻痹药物需要一定时间才能发挥作用,在等待过程中可能影响诊断和治疗的效率[12];最后,麻痹剂的药物持续作用可能对患者的日常生活产生不良影响,因此在使用时需考虑这些潜在的副作用和不便,难以用于大规模人群的视力筛查[13-14]。

2.2 UCVA 联合 NCAR 视力亦称视敏度或视锐度,是衡量视觉功能的重要指标[15]。根据儿童年龄的不同,常用视力参考值为:3~5 岁为 0.5,>6 岁为 0.7。如果视力低于以上标准可能存在屈光问题,甚至需警惕弱视的可能性[16-17]。目前国际上常用的视力表包括 LEA 符号视力表、HOVT 视力表和糖尿病视网膜病变早期治疗研究(early treatment of diabetic retinopathy study, ETDRS)视力表[18]。LEA 符号视力表适用于 3~4 岁认知和语言能力较差的儿童,通过图案识别来评估视力[19];HOVT 视力表通过恒定的拥挤效应提高了弱视诊断的敏感性[20];ETDRS 视力表是国际视力测量的金标准,具有良好的同质性和重复性[21]。在国内,1958 年缪天荣教授[22]研制的标准对数视力表被广泛使用,其在原先基础上按照一定的增率在 0.1~1.0之间插入了 8 行视标,视标按几何数级增加、视力记录按算术级增减,将第 11 行定为标准视力,记为 5.0,其视力标尺简化了大规模筛查的过程,并沿用至今。然而,视力表测量所得视力易受主观因素、灯箱亮度、测量误差以及睫状肌调节的影响,故可联合睫状肌非麻痹下的结果,减少由于睫状肌调节引起的误差,从而提高近视筛查的敏感性和特异性,特别适用于大规模学龄儿童的初步视力筛查[23-24]。一项 2019—2021 年期间进行的 5 次视力普查的研究共涉及 458 654 人次,基于裸眼远视力及非睫状肌麻痹验光度数,计算出了近视率、高度近视率及等效球镜屈光度,并绘制出了近视率的年增长趋势[25]。此外,张凤云等[26]对 7 441 名中小学生的分析结果显示,裸眼视力联合非睫状肌麻痹验光方案的受试者工作特征(receiver operating characteristic, ROC)曲线下面积为 0.91,灵敏度为 92.4%,特异度为 89.5%,约登指数为 0.82,表明该方案的真实性和预测值优于单独的裸眼视力检测或非睫状肌麻痹验光。但其筛查结果受到设备校准、环境光线以及测试人员技术水平等因素的影响,在大规模筛查中,设备和操作的一致性难以保证,可能会影响结果的准确性[27]。

2.3 轴率比 近年来由于眼科检查设备完善,视光学领域逐渐成为研究热点,眼部的一些生物学参数测量能够对近视的进展起到预测及评估作用。常见指标包括眼轴长度(axial length, AL)、角膜曲率半径(corneal radius of curvature, CR)、前房深度(anterior chamber depth, ACD)等,这些屈光指标随着儿童身体发育而不断改变。既往研究认为眼轴与近视密切相关,当眼轴持续增长超过正常范围即可能导致近视发生[28]。He 等[29]发现,眼轴长度与角膜曲率能够相互影响,CR 对 AL 的增大具有一定代偿作用,且两者与眼屈光程度密切相关。杜琦波[30]针对 340 名 4~16 岁儿童青少年的研究发现,AL/CR 与等效球镜度呈强相关,AL/CR 的 ROC 曲线下面积(诊断效能)为 0.97,诊断近视的灵敏度为 0.96,特异度为 0.39,对于近视的临床诊断价值较高。Ethan 等[31]在对 3 436 名 5~18 岁中国中小学生的大规模队列研究中提出,等效球镜度与 AL/CR 呈较强的负相关,AL/CR 检测近视的 ROC 曲线下面积(诊断效能)为 0.96,灵敏度和特异性分别为 87.0%,87.8%,可将其作为近视筛查或估算近视患病率的指标。González 等[32-33]将 AL/CR>3 作为诊断近视的阳性界值,可作为定性评估屈光状态的指标,其受主观因素和调节因素的干扰少,而且操作方便快捷,可对儿童青少年屈光状态进行定性分类,建议在大规模儿童青少年近视筛查建档时,应结合 AL/CR 指标,而非单独眼轴长度[34]。但目前尚缺乏社会大样本评估,没有建立相关随访屈光度档案,且动态预测评估近视效果尚不清楚,有文献指出轴率比与屈光度并非一一对应关系[35],目前只能粗略估计屈光状态,尚不能代替睫状肌麻痹验光金标准。

2.4 其他相关筛查方法 除上述方法评估儿童屈光程度外,许多眼科检查仪器也可根据不同应用对象的特点来进行筛查。单目 Suresight 视力筛查仪适用于

配合度低下的婴幼儿,检查速度快、操作简便,不需要对儿童头部进行固定,在半暗光条件下,调整至儿童模式,能用一种绿色的光圈吸引孩子的注意力,使摄像头与视线处于同一水平线上,可以快速对婴儿的屈光状况有一个初步的了解[36]。有研究指出,相比于在非麻痹下状态下验光[37],Suresight 视力筛查仪所测得结果更接近于睫状肌麻痹后结果,这与调至儿童模式下,仪器尽可能消除了调节相关因素,并对屈光数据的输出值做了相应调整有关。Spot 双目视力筛查仪则能用于双眼屈光度筛查,并可初步评估眼位情况,排除内斜、外斜等对屈光不正潜在的影响。相较于 Suresight 视力筛查仪,Spot 双目视力筛查仪所测得儿童屈光状态具有更好的特异度和灵敏度,但相较于金标准,使用 Spot 双目筛查较易低估儿童的远视储备,可能由儿童适应过程中不可控的调节所致[38],且一些设置参数必须根据具体临床环境进行设定。总体而言,Suresight 视力筛查仪适用于需要详细单眼视力评估的场景,特别是在环境相对简单的测试设置中。该设备具备自动化设置程序,有效减少了由于操作人员技术水平差异引起的人为误差。然而,由于其单眼评估的局限性,可能无法全面评估双眼融合功能及屈光参差等问题。相比之下,Spot 双目视力筛查仪更适合快速且大规模的视力筛查,能够同步评估双眼视力及协调性。但由于个体差异,该仪器在某些测试中可能无法详细评估每只眼睛的个别问题[39],同时其较高的设备成本和检查费用也是一个需考虑的因素。因此,设备的选择应根据筛查的具体需求、预算和操作环境进行综合考虑。

3　小结与展望

现代视力筛查方案通常依赖于精密的眼科检查设备,因此操作人员需要熟练掌握相关技术,并在相同环境下进行多次测量,以减少环境因素对数据一致性和准确性的影响。在进行非麻痹下睫状肌验光时,由于儿童的眼部调节能力较强,使用此方法时可能与真实屈光状态存在较大偏差,因此建议结合裸眼视力进行综合判断。对于配合程度较低的儿童,或无法使用散瞳药物的婴幼儿及学龄前儿童,可使用 Suresight 筛查仪,并通过图像和动画设备吸引其注意力,以快速评估屈光状态;若怀疑存在异常眼位情况,则可使用 Spot 筛查仪进行初步判断。眼轴、角膜曲率等是决定眼屈光能力的重要生物学指标,可能会随着年龄的增长而变化,在对近视学龄期儿童及青少年进行动态监测时,应合理安排测量时间间隔,以观察其变化趋势并评估防控效果[40],甚至可联合运用多种机器学习算法,以眼轴、轴率比年增加量为参数,建立相关模型,用以预测近视度数,精准评估近视防控措施的效果[41-42]。但由于个体差异以及缺乏大样本屈光档案数据,其动态评估近视进展作用尚不明确,仍需不断研究,探索更加有效、简便、准确的屈光筛查方案。

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