·Duchenne型肌营养不良症基础与临床研究·

定量等长肌力测定在Duchenne型和Becker型肌营养不良症患儿下肢肌力测定中的信度评价

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【摘要】 **目的** 评价定量等长肌力测定在Duchenne型和Becker型肌营养不良症患儿下肢肌力测定中的信度。**方法** 共21例Duchenne型(19例)和Becker型(2例)肌营养不良症患儿,采用手持式肌力测定仪检测患儿髋、膝、踝等部位肌群肌力,比较不同检测者间和同一检测者两次测试结果间的相关性,以评价手持式肌力测定仪的不同检测者间信度和重测信度。**结果** 手持式肌力测定仪测定Duchenne型和Becker型肌营养不良症患儿下肢肌群具有良好的不同检测者间信度(*ICC* = 0.762 ~ 0.978)和重测信度(*ICC* = 0.690 ~ 0.938),但二者对远端肌群(足跖屈和足背屈)信度均相对较低。**结论** 手持式肌力测定仪在Duchenne型和Becker型肌营养不良症患儿下肢肌力测定中具有较好的不同检测者间信度和重测信度,可以用于监测肌力变化和评价临床疗效。

【关键词】 肌营养不良,杜氏; 肌力; 下肢

Reliability of hand - held dynamometry for measurement of lower limb muscle strength in children with Duchenne and Becker muscular dystrophy

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【**Abstract**】 **Objective** To determine the reliability of hand-held dynamometry (HHD) for lower limb isometric muscle strength measurement in children with Duchenne and Becker muscular dystrophy (DMD/BMD). **Methods** A total of 21 children [20 males and one female; mean age was (7.88 ± 2.87) years, ranging between 3.96–14.09 years; mean age at diagnosis was (5.88 ± 2.88) years, ranging between 1.35–12.89 years; mean height was (120.64 ± 16.30) cm, ranging between 97–153 cm; mean body weight was (24.62 ± 9.05) kg, ranging between 14–50 kg] with DMD (19/21) and BMD (2/21) were involved from Rehabilitation Center of Children's Hospital of Fudan University. The muscle strength of hip, knee and ankle was measured by HHD under standardized test methods. The test-retest results were compared to determine the inter-test reliability, and the results among testers were compared to determine the inter-tester reliability. **Results** HHD showed fine inter-tester reliability (*ICC* = 0.762–0.978) and inter-test reliability (*ICC* = 0.690–0.938) in measuring lower limb muscle strength of children with DMD/BMD. Results also showed relatively poor reliability in distal muscle groups (foot plantar flexion and dorsiflexion). **Conclusions** HHD, showing fine inter-tester and inter-test reliability in measuring the lower limb muscle strength of children with DMD/BMD, can be used in monitoring muscle strength changing and assessing effects of clinical interventions.

【**Key words**】 Muscular dystrophy, Duchenne; Muscle strength; Lower extremity

Duchenne型肌营养不良症(DMD)和Becker型肌营养不良症(BMD)是临床最为常见的X连锁隐性遗传性疾病,二者在活产男婴中的发病率分别约为1/3500和1/12000[1]。研究显示,Duchenne型和Becker型肌营养不良症均系*DMD*基因突变所致,该基因分布于骨骼肌和心肌细胞胞膜,起细胞支架作用,具有维持肌纤维完整性和抗牵拉功能,主要突变类型为部分缺失或重复,无法合成正常的抗肌萎缩蛋白(dystrophin),使肌纤维变性、坏死和再生[2],进而导致肌力下降。进行性肌力下降是Duchenne型和Becker型肌营养不良症的主要临床表现,因此,肌力测定是判断病程进展和治疗效果的重要指

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标。目前，临床最常用的肌力评价指标是医学研究学会（MRC）制定的徒手肌力测定（MMT）[3]，但也有学者认为该方法敏感性较低，主张定量检测以提高肌力测定的精确性[4]。尽管国际上早已采用手持式肌力测定仪（HHD）评价Duchenne型和Becker型肌营养不良症患者等长肌力状况[5-6]，但是由于其所检测的肌群、部位和方法尚无统一标准，因此并未在临床广泛应用。鉴于此，本研究旨在规范手持式肌力测定仪检测Duchenne型和Becker型肌营养不良症患儿髋、膝、踝等部位肌群肌力的具体操作方法，同时验证该方法不同检测者间信度和重测信度，以为手持式肌力测定仪在国内Duchenne型和Becker型肌营养不良症患者中的应用提供更多的临床实践证据。

对象与方法

一、研究对象

1. 纳入标准 （1）Duchenne型和Becker型肌营养不良症的诊断均符合以下标准：①通常于5岁前发病，初始症状多为走路易跌倒、鸭步步态。②进行性对称性肌无力，以肢体近端肌肉受累多见，常自下肢起病。③无肌肉震颤、感觉障碍，多伴腓肠肌假性肥大。④血清肌酸激酶（CK）水平升高数十或数百倍。⑤肌电图呈现肌源性损害。⑥病情进行性加重。（2）本研究经复旦大学附属儿科医院医学伦理委员会审核批准，所有患儿及其监护人均知情同意并签署知情同意书。

2. 排除标准 （1）未行肌肉活检或基因检测的疑似患儿。（2）其他类型肌营养不良症患儿。（3）伴智力障碍影响肌力测定的患儿。

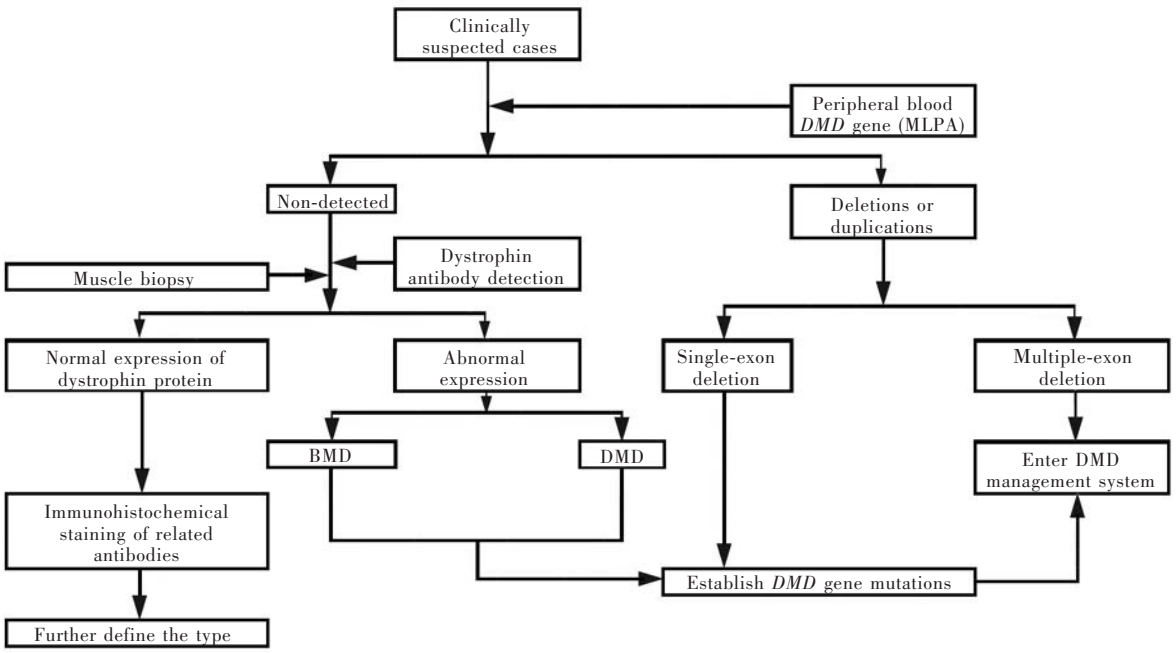
3. 一般资料 选择2014年2–11月在复旦大学附属儿科医院康复科行功能评价和康复干预的Duchenne型和Becker型肌营养不良症患儿共21例，男性20例，女性1例；年龄3.96～14.09岁，平均（7.88±2.87）岁；明确诊断年龄1.35～12.89岁，平均（5.88±2.88）岁；身高97～153 cm，平均（120.64±16.30）cm；体重14～50 kg，平均（24.62±9.05）kg。其中，Duchenne型肌营养不良症19例，Becker型肌营养不良症2例。所有患者均经基因检测或肌肉活检而明确诊断，诊断流程参见图1，所有患儿均能理解肌力测定中的大部分指令并配合完成测试。本组21例Duchenne型和Becker型肌营养不良症患儿的一般资料参见表1。

二、研究方法

1. 手持式肌力测定仪检测 （1）仪器：采用美国Ametek公司生产的X3328-200型手持式肌力测定仪，由主体和各类型适配器组成，检测时主体与选定的适配器（均采用凹面适配器）相连接，适配器直接与患儿受检部位接触，主体显示肌力测定结果。本研究采用肌力测试试验模式，输出结果的测量范围为0～100 kg，刻度单位为0.01 kg。（2）检测方法：检测患儿髋、膝、踝等部位肌群肌力，参照脑性瘫痪患儿手持式肌力测定仪标准化操作方法[7]，结合Duchenne型和Becker型肌营养不良症患儿肌肉活动特性进行相应调整（主要针对髋外展、足跖屈和足背屈肌群），所检测肌群、患儿体位、手持式肌力测定仪摆放位、患儿或检测者用力方向参见表2。当检测者发出“预备，使劲用力”口令后，患儿于3～5 s内全力进行等长肌肉收缩以抵抗适配器，检测者同时尽力保持手持式肌力测定仪摆放位稳定；若患儿未用全力、体位保持不稳或检测者未能准确保持手持式电子肌力测定仪摆放位，可重复测试，但不宜超过3次，取最大值。

2. 信度评价 包括不同检测者间信度和重测信度。（1）不同检测者间信度评价：由1位具有10年以上经验的康复治疗师进行手持式肌力测定仪检测，1位实习治疗师同时在现场进行数据记录，按照患儿坐位（有靠背的座椅）、仰卧位和俯卧位（双侧有扶手的物理治疗床）的顺序进行髋屈曲、髋伸展、髋外展、膝屈曲、膝伸展、足跖屈、足背屈共7组肌群肌力测定，完成测试后，嘱患儿休息10 min，休息期间不能进行剧烈活动，再由另1位具有8年经验的康复治疗师进行重复测试，比较两次测试结果的相关性以检验不同检测者间信度。上述测试均于上午进行。（2）重测信度评价：患儿均于测试当天下午再次接受重复测试，由第1位检测者实施，要求与上午测试时间至少间隔4 h，期间不能进行与肌力相关的康复干预和剧烈活动，比较两次测试结果的相关性以检验重测信度。

3. 统计分析方法 采用SPSS 17.0统计软件进行数据处理与分析。各组肌群信度评价采用组内相关系数（*ICC*），其中不同检测者间信度采用$ICC_{2,2}$，重测信度采用$ICC_{2,1}$，*ICC* < 0.400为信度不理想，0.400～0.600为信度中等，>0.600～0.800为信度良好，>0.800～1.000为信度极好[8]。以$P \leq 0.05$为差异具有统计学意义。



MLPA, multiplex ligation-dependent probe amplication, 多重连接依赖性探针扩增; BMD, Becker muscular dystrophy, Becker型肌营养不良症; DMD, Duchenne muscular dystrophy, Duchenne型肌营养不良症

图1 Duchenne型和Becker型肌营养不良症诊断流程
Figure 1 Diagnostic process for DMD/BMD.

结　果

一、各组肌群肌力测定

本组有7例患儿俯卧位髋伸展肌群肌力明显减弱，无法完成抗阻力运动，2例患儿不能理解髋伸展肌群测试指令而无法完成测试，其余各组肌群均获得肌力测定结果。由表3可见，7组肌群肌力最大的前3位分别为足跖屈、膝屈曲和髋外展，肌力最小的是足背屈（髋伸展除外）。

二、各组肌群信度评价

表4结果显示，手持式肌力测定仪检测Duchenne型和Becker型肌营养不良症患儿下肢肌群具有良好的不同检测者间信度（*ICC* = 0.762 ~ 0.978），但远端肌群（足跖屈和足背屈）信度相对较低；亦具有良好的重测信度（*ICC* = 0.690 ~ 0.938），但远端肌群信度相对较低。

讨　论

与徒手肌力测定相比，手持式肌力测定仪测定肌群最大自主等长收缩肌力更可靠、客观和准确，此外，与需要在特定场所才能完成的等速肌力测定相比，手持式肌力测定仪便于携带、更为简便[9]。手持式肌力测定仪已在国际上广泛应用于儿童各种类型疾病，如脑性瘫痪[7]、颅脑创伤[10]、脊髓性肌萎缩症（SMA）[11]、唐氏综合征[12]等。信度是确定随机测量误差对测量结果的影响程度，可以作为评价测量工具的主要指标之一。Stuberg和Metcalf[6]最早报告手持式肌力测定仪在Duchenne型肌营养不良症患儿中的重测信度，共纳入14例患儿，平均年龄11.30岁，检测膝伸展、肘屈曲、髋伸展、肩外展4组肌群，采用Pearson相关分析评价各组肌群的重测信度，结果显示，4组肌群均有较好的重测信度（r = 0.830 ~ 0.990）。此后，Brussock等[5]报告10例平均年龄10.20岁的Duchenne型肌营养不良症患儿，评价手持式肌力测定仪的不同检测者间信度和重测信度，检测肘伸展、髋屈曲、膝屈曲和足背屈等肌群，不同检测者间信度*ICC*值为0.740 ~ 0.970，重测信度*ICC*值为0.880 ~ 0.990。与上述两项研究相比，本研究纳入更多的下肢肌群（共7组肌群），结果显示，手持式肌力测定仪具有良好的不同检测者间信度（*ICC* = 0.762 ~ 0.978）和重测信度（*ICC* = 0.690 ~ 0.938）。

表1　21例Duchenne型和Becker型肌营养不良症患儿一般资料

Table 1.　General data of 21 children with DMD/BMD

Case	Category	Diagnostic basis	Sex	Age (year)	Age diagnosis (year)	Height (cm)	Weight (kg)
1	*DMD*	Muscle biopsy	Male	10.40	5.29	133.00	30.00
2	*DMD*	Muscle biopsy	Male	4.43	3.23	105.00	16.50
3	*DMD*	Muscle biopsy	Male	4.75	4.05	109.00	20.00
4	*DMD*	Muscle biopsy	Male	10.88	8.98	135.00	40.00
5	*DMD*	Exon 44 duplication Exon 72–79 duplication	Male	7.78	7.28	132.00	26.00
6	*DMD*	Muscle biopsy	Male	8.95	4.74	137.00	35.00
7	*DMD*	Exon 48–49 deletion	Male	10.93	3.41	136.00	31.00
8	*DMD*	Muscle biopsy	Male	4.08	3.53	97.00	14.00
9	*DMD*	Muscle biopsy	Male	7.07	1.35	114.00	20.50
10	*DMD*	Exon 45–54 deletion	Male	11.58	9.11	140.00	29.00
11	*DMD*	Exon 43–44 deletion	Male	9.45	9.23	134.00	26.00
12	*DMD*	Exon 7 deletion	Male	9.88	9.81	132.00	28.00
13	*DMD*	Exon 60 deletion	Male	7.63	5.13	108.50	21.00
14	*DMD*	Muscle biopsy	Male	9.72	5.43	120.00	20.00
15	*DMD*	Exon 45–52 deletion	Male	6.19	6.17	109.00	19.00
16	*DMD*	Muscle biopsy	Female	14.09	12.89	153.00	50.00
17	*DMD*	Exon 45–50 deletion	Male	4.98	4.85	98.00	15.00
18	*DMD*	Exon 45–53 deletion	Male	3.96	3.89	110.00	19.00
19	*DMD*	Muscle biopsy	Male	5.10	2.12	105.00	18.00
20	*DMD*	Muscle biopsy	Male	8.09	7.72	126.00	24.00
21	*DMD*	Exon 46–52 deletion	Male	5.52	5.29	100.00	15.00

患儿对测试指令的理解程度、体位、肌力和肌肉状况等均是影响Duchenne型和Becker型肌营养不良症手持式肌力测定仪检测误差的主要因素。尽管有文献报道，部分Duchenne型肌营养不良症患儿存在智力障碍[13]，但与脑性瘫痪患儿对多组肌群测试指令理解困难相比[7]，本研究仅有2例患儿对测试指令理解困难而未完成测试，可能是由于Duchenne型肌营养不良症患儿智力障碍发生率较低或程度较轻。

采用双侧有扶手的物理治疗床，可以有效保持患儿体位的稳定性，避免由于体位不稳而影响测试信度。本研究采用侧卧位检测髋外展肌群，以消除仰卧位时与垫子间的摩擦力而引起的误差，采用仰卧位屈膝90°同时固定小腿以悬空足部的方法测试足跖屈和足背屈肌群，以避免足跟直接接触垫子而可能产生的借力作用。本研究结果显示，远端肌群（足跖屈和足背屈）的不同检测者间信度和重测信度均相对较低，与Florence等[14]的研究结果相似，可能是由于与其他部位肌群相比，远端肌群体位固定较为困难所致；也可能是由于Duchenne型和Becker型肌营养不良症患儿易较早出现踝关节挛缩。与其他部位肌群相比，远端肌群肌力测定更早地附加了关节活动度对测量误差的影响。

日常生活活动可能影响患儿肌力而使肌力测定结果不稳定，因此建议，测试前予以受试者充分的休息、避免各类可能影响肌力的活动，手持式肌力测定仪检测尽可能在固定时间段进行（如早餐后8:00～10:00），以尽量减少测量误差。

综上所述，手持式肌力测定仪在Duchenne型和Becker型肌营养不良症患儿下肢肌力测定中具有较好的不同检测者间信度和重测信度，既可用于监测Duchenne型和Becker型肌营养不良症患儿肌力状况[15]，又可用于评价新近各种治疗方法的效果[16]。然而，手持式肌力测定仪仅能够针对各组肌群分别开展测试，难以像徒手肌力测定一样整合以整体评价患儿肌力状况[17]。而且，肌力低于3级时，手持式肌力测定仪通常不能测出有效数据，因此需要采用定量与定性相结合的方法才能够全面反映

表2 手持式肌力测定仪标准化操作方法[7]

Table 2. Standardized operational approach of HHD[7]

Muscle group	Major muscle	Operational approach
Hip flexors	Iliopsoas, rectus femoris, tensor fasciae latae, sartorius	Sitting with feet dangling, hip and knee flexed 90°; resistance at anterior thigh immediately proximal to knee above superior border of patella. Let tester flex his hip
Hip extensors	Gluteus maximus, biceps femoris muscle, semitendinosus, semimembranosus	Prone, knee flexed 90°and hip extended off surface; resistance to posterior thigh immediately proximal to popliteal crease. Let tester extends his hip
Hip abductors	Gluteus medius, gluteus minimus	Lateral position, knee and hip held in natural extended position, hip held in neutral position. Keep pelvis steady and avoid sliding (tester can use his upper limb and fixing band to help steady); resistance to lateral thigh 2 cm above the knee. Let tester abduce his hip and keep resisting for 3–5 s. We should stop testing and restart if tester can not keep his pelvis steady
Knee flexors	Semitendinosus, semimembranosus, biceps femoris muscle, popliteus muscle, sartorius, gracilis, musculus gastrocnemius	Sitting with feet dangling, knee flexed 90°; popliteal space close to the edge of a bed; resistance to posterior tibia just proximal to bimalleolar line. Let tester flex his knee
Knee extensors	Quadriceps femoris	Sitting with feet dangling, knee flexed 90°; popliteal space close to the edge of a bed; resistance to anterior tibia just proximal to bimalleolar line. Let tester extend his knee
Ankle plantar flexors	Triceps surae, flexor digitorum longus, tibialis posterior, peroneus longus and brevis muscles	Supine, knee flexed 90°, keeping calf fixed and steady and foot held in plantar position; resistance to plantar surface of metatarsal heads. The direction of force is according to the direction of arrow on the picture. At the same time, let tester keep resisting for 3–5 s
Ankle dorsiflexors	Tibialis anterior, extensor digitorum longus, fibularis tertius	Supine, knee flexed 90°, keeping calf fixed and steady and foot held in natural resting position, resistance to dorsal surface of metatarsal heads. Let tester dorsiflex his ankle

表3 7组肌群肌力测定结果($\bar{x} \pm s$, kg)

Table 3. Results of strength measurement of 7 muscle groups ($\bar{x} \pm s$, kg)

Muscle group	N	Tester A (1st)	Tester A (2nd)	Tester B
Hip flexors				
Left	21	7.00 ± 3.78	6.99 ± 4.30	7.65 ± 4.48
Right	21	7.64 ± 4.26	7.04 ± 3.86	8.02 ± 4.19
Hip extensors				
Left	12	6.67 ± 4.52	7.08 ± 4.06	6.67 ± 3.70
Right	12	7.54 ± 4.59	7.20 ± 4.41	6.72 ± 4.21
Hip abductors				
Left	21	9.67 ± 6.09	8.98 ± 5.61	8.70 ± 5.43
Right	21	9.32 ± 6.87	8.83 ± 5.15	8.28 ± 4.78
Knee flexors				
Left	21	7.85 ± 4.74	8.74 ± 5.77	8.37 ± 5.70
Right	21	9.45 ± 5.75	9.45 ± 6.02	9.63 ± 5.74
Knee extensors				
Left	21	7.17 ± 4.55	7.57 ± 4.54	8.30 ± 4.57
Right	21	7.86 ± 6.18	7.83 ± 6.59	9.21 ± 7.02
Ankle plantar flexors				
Left	21	12.22 ± 8.02	11.47 ± 7.56	11.61 ± 6.81
Right	21	12.68 ± 8.61	13.12 ± 10.34	13.16 ± 9.55
Ankle dorsiflexors				
Left	21	5.43 ± 3.21	5.58 ± 3.28	5.84 ± 3.03
Right	21	5.76 ± 4.28	5.71 ± 3.73	6.03 ± 3.60

表4 7组肌群肌力测定不同检测者间信度和重测信度评价

Table 4. Inter-tester and inter-test reliability of strength measurement of 7 muscle groups

Muscle group	Inter-tester reliability		Inter-test reliability	
	ICC	95%CI	*ICC*	95%CI
Hip flexors				
Left	0.940	0.851–0.976	0.833	0.633–0.929
Right	0.914	0.789–0.965	0.908	0.787–0.962
Hip extensors				
Left	0.893	0.667–0.966	0.822	0.493–0.945
Right	0.866	0.583–0.957	0.918	0.743–0.976
Hip abductors				
Left	0.956	0.889–0.983	0.938	0.854–0.974
Right	0.978	0.945–0.991	0.833	0.633–0.929
Knee flexors				
Left	0.926	0.819–0.973	0.902	0.774–0.959
Right	0.913	0.785–0.965	0.871	0.709–0.945
Knee extensors				
Left	0.935	0.839–0.973	0.911	0.794–0.963
Right	0.937	0.845–0.975	0.888	0.745–0.953
Ankle plantar flexors				
Left	0.860	0.656–0.943	0.690	0.377–0.861
Right	0.823	0.563–0.928	0.851	0.669–0.937
Ankle dorsiflexors				
Left	0.762	0.413–0.903	0.813	0.595–0.920
Right	0.886	0.718–0.954	0.891	0.751–0.954

Duchenne型和Becker型肌营养不良症患儿的肌力状况[18-19]。

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