Mariana Cunha Artilheiro

**Avaliação da função do membro superior em pacientes com
Distrofia Muscular de Duchenne**

Tese apresentada à Faculdade de Medicina
da Universidade de São Paulo para
obtenção do título de Doutora em Ciências

Programa de Ciências da Reabilitação

Orientadora: Prof. Dr. Mariana Callil Voos

SÃO PAULO

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DEDICATÓRIA

Esta Tese e todo o estudo de oito anos e meio após ter me graduado fisioterapeuta são dedicados aos pacientes com doenças neuromusculares, mais especificamente aos meninos e meninas com distrofia muscular.

Ser fisioterapeuta dessas pessoas é participar da história e do caminho de vida deles e de suas famílias. É um privilégio ter a possibilidade de pesquisar formas de contribuir com a prática fisioterapêutica baseada em evidências na distrofia muscular. É gratificante me aperfeiçoar na profissão estudando essa área, que é tão importante.

Que as pesquisas sobre distrofias musculares sejam continuamente alimentadas. É uma honra proporcionar mais conforto para os nossos pacientes.

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A Deus e todos os espíritos de luz que me protegem, guiam meus caminhos e possibilitam conquistas especiais nesta vida.

“Junte novas pedras e construa novos poemas.

Recrie a tua vida, sempre.

Remova as pedras e plante roseiras.

Recomece.

*Faça de tua vida um poema e viverás no coração dos
jovens e na memória das gerações que hão de vir.*

Esta fonte é para uso de todos.

Toma a tua parte.

Vem a estas páginas e não entrave seu uso

aos que têm sede.”

(Trecho adaptado de poema de Cora Coralina)

NORMALIZAÇÃO ADOTADA

Esta Tese está de acordo com as seguintes normas, em vigor no momento desta publicação:

Referências: adaptado de *International Committee of Medical Journals Editors* (Vancouver).

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RESUMO

Artalheiro MC. *Avaliação da função do membro superior em pacientes com Distrofia Muscular de Duchenne* [Tese]. São Paulo: Faculdade de Medicina, Universidade de São Paulo; 2018.

Os movimentos do membro superior na distrofia muscular de Duchenne devem ser avaliados para acompanhar a evolução clínica e estabelecer abordagens terapêuticas. Testes que cronometram o desempenho em tarefas funcionais representam uma forma precisa de avaliar a independência funcional e monitorar a progressão da doença. O tempo necessário para a realização de uma tarefa pode refletir a evolução e prever a habilidade funcional. Contudo, o desempenho pode ser influenciado por movimentos compensatórios, que são comumente adotados para a manutenção da independência funcional. Esta Tese é composta por quatro artigos científicos, que objetivaram: (1) investigar a relação entre as características cinesiológicas, avaliadas pelo teste *Performance of Upper Limb* e tempo no Teste de Jebsen-Taylor; (2) investigar possíveis diferenças e relações entre o desempenho do membro superior dominante e do membro superior não-dominante de pacientes com distrofia muscular de Duchenne e comparar o desempenho dos pacientes com o de controles saudáveis; (3) descrever a confiabilidade teste-reteste e a consistência interna dos tempos de pacientes com distrofia muscular de Duchenne no Teste de Jebsen-Taylor e (4) comparar os movimentos

compensatórios de pacientes e controles saudáveis na tarefa de levar uma colher à boca. Os quatro estudos foram realizados de forma prospectiva observacional. Os resultados mostraram que (1) o Teste de Jebsen-Taylor está correlacionado com o Teste padrão-ouro (*Performance of Upper Limb*) e o tempo reflete a função motora de membros superiores de pacientes com distrofia muscular de Duchenne; (2) não há diferença na assimetria entre os membros superiores de pacientes quando comparados a indivíduos saudáveis; o desempenho do membro superior dominante é fortemente correlacionado com o do membro superior não-dominante; (3) o Teste de Jebsen-Taylor possui boas propriedades psicométricas e (4) ao levar uma colher à boca, pacientes realizam movimentos compensatórios, como aumento da flexão de cabeça e de cotovelo. Como conclusão, o Teste de Jebsen-Taylor contribui para a avaliação da função motora do membro superior em pacientes com distrofia muscular de Duchenne, por meio da medida do tempo e dos movimentos compensatórios. Os dados normativos apresentados nesta Tese podem ser usados como parâmetros para acompanhamento clínico e terapêutico de pacientes com distrofia muscular de Duchenne.

Descritores: distrofia muscular de Duchenne; distrofias musculares; extremidade superior; avaliação da deficiência; modalidades de fisioterapia; reabilitação.

ABSTRACT

Artilheiro MC. *Assessment of upper limb function of patients with Duchenne muscular dystrophies* [thesis]. São Paulo: “Faculdade de Medicina, Universidade de São Paulo”; 2018.

The upper limb movements in Duchenne muscular dystrophy must be evaluated to monitor clinical evolution and establish therapeutic approaches. Tests that measure timed performance on functional tasks represent an accurate way of assessing functional independence and monitoring disease progression. Timed performance can accurately reflect evolution and predict functional skills. However, performance can be influenced by compensatory movements that are commonly adopted to maintain functional independence. This Thesis comprises four articles that aimed to: (1) investigate the relationship between the kinesiological characteristics evaluated by Performance of Upper Limb test and timed performance of the Jebsen-Taylor Test; (2) to investigate possible differences and relationships between the performance of the dominant and the non-dominant upper limbs of patients with Duchenne muscular dystrophy and to compare the performance of patients with healthy controls; (3) describe the timed performance of patients with muscular dystrophy and to investigate the test-retest reliability and internal consistency of the Jebsen-Taylor Test and (4) compare the compensatory movements of patients and healthy controls in bringing a spoon to the mouth. The four studies were observational and prospective. The results showed that (1) Jebsen-Taylor Test is strongly

correlated to the gold standard test (Performance of Upper Limb) and timed performance reflects upper limb motor function in patients with Duchenne muscular dystrophy; (2) upper limbs asymmetry in patients with Duchenne muscular dystrophy is not higher than in healthy individuals, and the dominant upper limb performance is strongly correlated to the non-dominant upper limb performance; (3) Jebsen-Taylor test has good psychometric properties and (4) patients perform compensatory movements while bringing a spoon to the mouth, as increased head flexion and increased elbow flexion. In conclusion, Jebsen-Taylor test contributes to upper limb motor function assessment in patients with Duchenne muscular dystrophy, as it measures time and compensatory movements. This thesis provides normative data that can be parameters for clinical and therapeutic follow up of patients with muscular dystrophy.

Descriptors: *muscular dystrophy, Duchenne; muscular dystrophies; upper extremity; disability evaluation; physical therapy modalities; rehabilitation.*

APRESENTAÇÃO

Meu trajeto na pós-graduação iniciou-se em 2010, quando me matriculei no Programa Ciências da Reabilitação (Mestrado), da Universidade Nove de Julho. O estudo da avaliação dos membros superiores de pacientes com distúrbios do movimento, desenvolvido nesse período, resultou na Dissertação intitulada “Análise tridimensional do movimento de membros superiores com uso de pulseira de peso em adultos jovens saudáveis e com Paralisia Cerebral do tipo discinético”, publicada em 2014 na Revista *Gait & Posture*. O interesse em estudar a função dos membros superiores foi impulsionado pela escassez de escalas específicas, bem como de evidências que embasassem práticas clínicas na reabilitação dos membros superiores, em comparação ao número de estudos relacionados ao tratamento das disfunções dos membros inferiores. Os movimentos dos membros superiores que permitem a independência para as atividades de vida diária.

Durante o mestrado, a avaliação por meio de sistemas de análise tridimensional possibilitou a avaliação quantitativa dos movimentos e das alterações funcionais dos membros superiores de pacientes com discinesias. Esta forma de avaliação representa o padrão-ouro de mensuração de movimento. Porém, não são todos os centros de reabilitação e até mesmo os grandes centros de pesquisa do país que o possuem. Os que possuem, utilizam a ferramenta prioritariamente para fins de pesquisa e não adotam a mesma como prática corriqueira de mensuração de resultados clínicos de ganhos funcionais ou mesmo para acompanhamento da evolução clínica. Idealmente, a avaliação fisioterapêutica dos membros superiores - inicial e

contínua - deve ser realizada por meio de instrumentos acessíveis e disponíveis ao fisioterapeuta ou terapeuta ocupacional no dia-a-dia da prática clínica. Devido à falta de escala específica para avaliação dos membros superiores nas discinesias, foi realizada revisão de literatura dos instrumentos quantitativos de mensuração de desempenho ou função motora. Essa revisão permitiu constatar a falta de especificidade das escalas e verificar a possibilidade de um caminho necessário e promissor para a pesquisa sobre avaliação da função motora dos membros superiores.

No ano de conclusão do mestrado (2011), iniciei a atuação profissional na Associação Brasileira de Distrofia Muscular. Em 2012, realizei o curso de especialização “Intervenções Fisioterapêuticas nas Doenças Neuromusculares” da Universidade Federal de São Paulo (UNIFESP). Sob a orientação da Prof. Dra. Cristina dos Santos Cardoso de Sá e coorientação da Prof. Dra. Francis Meire Fávero, desenvolvemos a monografia que objetivou analisar as ferramentas clínicas de avaliação do desempenho manual em pacientes com distrofia muscular. Uma revisão de literatura dos instrumentos desenvolvidos para a população neuromuscular possibilitou apontar deficiências das escalas existentes e sugerir o aprofundamento do estudo da aplicabilidade do Teste de Jebsen-Taylor nas distrofias musculares. Constatamos que o teste havia sido aplicado anteriormente em meninos com distrofia muscular de Duchenne. Contudo, vinha sendo pouco explorado desde então. Os resultados mostraram que o teste era viável e adequado para avaliação dessa população (tanto os procedimentos, quanto a utilização do tempo como forma de mensuração de desempenho). A apresentação da monografia foi realizada em 2013. A banca

foi composta pela Profa. Dra. Fátima Caromano, docente do Programa de Pós-graduação em Ciências da Reabilitação da Universidade de São Paulo (USP), que contribuiu com sugestões para aperfeiçoamento do projeto e incentivou a continuidade da pesquisa em forma de tese de doutorado.

A matrícula no Programa Ciências da Reabilitação da USP (Doutorado) se deu em maio de 2015, mas entre 2013 e 2015 tive a possibilidade de colaborar em estudos dos grupos da Profa. Dra. Fátima Caromano e da Profa. Dra. Mariana Callil Voos. Elaborei o projeto de pesquisa do doutorado (Projeto aprovado pelo Comitê de Ética em Pesquisa do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, sob parecer número 1.755.008, Anexos 1 e 2). Ao final de 2015, houve a transferência da orientação para a Profa. Dra. Mariana Callil Voos. A partir deste momento iniciei o aperfeiçoamento do estudo sobre a utilização do tempo como instrumento de avaliação da função motora dos membros superiores nas distrofias musculares.

A primeira etapa consistiu em comparar a utilização do Teste de Jebsen-Taylor (Anexo 3) em pacientes com distrofia muscular de Duchenne com o Teste *Performance of Upper Limb*, padrão ouro de avaliação dos membros superiores (Anexo 4). O estudo visou investigar a relação entre a pontuação do Teste *Performance of Upper Limb* e o tempo no Teste de Jebsen-Taylor em pacientes com distrofias musculares (não somente a distrofia muscular de Duchenne). Encontramos que as características cinesiológicas do Teste *Performance of Upper Limb* e o tempo no Teste de Jebsen-Taylor são fortemente relacionados. A correlação negativa forte foi encontrada entre a

pontuação total dos testes e, de maneira específica, entre as dimensões de ombro, cotovelo e punho do Teste *Performance of Upper Limb* e alguns subtestes do Teste de Jebsen-Taylor. Os dados parciais desse trabalho foram apresentados no 4º Congresso Brasileiro de Fisioterapia Neurofuncional e publicados nos Anais do evento, em 2016 (*Relationship between Jebsen-Taylor Test and Performance of Upper Limb in Duchenne Muscular Dystrophy*", Anexo 5). O estudo foi publicado na Revista *Perceptual and Motor Skills* com o título "*Hand function in Muscular Dystrophies: relationship between Performance of Upper Limb and Jebsen-Taylor Tests*". Concluímos que o tempo pode ser uma alternativa à avaliação cinesiológica do Teste *Performance of Upper Limb*. Comumente a queixa do paciente ou familiar é relacionada com lentidão de execução de tarefas cotidianas ou a frequência de necessidade de assistência de terceiros, o que pode ser detectado pelo Teste de Jebsen-Taylor.

A segunda etapa visou responder as seguintes perguntas: há relação entre o tempo, função motora, força muscular e idade? Há relação entre o desempenho do membro superior dominante com relação ao não dominante? Há assimetria entre os membros superiores de pacientes com distrofia muscular? Há assimetria entre os membros superiores de pacientes com distrofia muscular em relação aos controles saudáveis? Encontramos correlação forte entre tempo, função motora e força muscular, correlação forte e ausência de assimetria entre o desempenho dos membros superiores de pacientes com distrofia muscular. Além disso, não encontramos diferenças de assimetria entre os membros superiores de pacientes com distrofia muscular em relação aos controles saudáveis. Os dados parciais do segundo trabalho

foram apresentados em forma de pôster no XXVII Congresso Brasileiro de Neurologia. O resumo foi publicado nos Anais do evento (suplemento da Revista Arquivos de Neuropsiquiatria (*“Patients with Duchenne Muscular Dystrophy are not more asymmetrical than healthy controls in functional timed upper limbs tasks”*, Anexo 6). Esse segundo estudo foi publicado na Revista *Brazilian Journal of Medical and Biological Research*, com o título *“Patients with Duchenne and Becker muscular dystrophies are not more asymmetrical than healthy controls in functional timed upper limbs tasks”*.

Para descrever a aplicação do Teste de Jebsen-Taylor e avaliar as propriedades psicométricas do mesmo em pacientes com Distrofias Musculares, desenvolvemos um terceiro estudo. Este objetivou descrever o desempenho no teste Jebsen-Taylor em pessoas com distrofia muscular e investigar a confiabilidade teste-reteste e a consistência interna. Como resultados, encontramos que o Teste de Jebsen-Taylor é uma medida confiável para avaliação da função de membros superiores em pacientes com distrofias musculares e apresenta alta concordância no desempenho total. Além disso, a descrição do tempo fornece dados normativos para comparação em futuros estudos. O estudo foi publicado na Revista Brasileira de Fisioterapia com o título *“Brazilian Journal of Physical Therapy (‘Reliability, validity and description of timed performance of the Jebsen-Taylor Test in patients with muscular dystrophies’*.

O tempo pode ser influenciado pelos movimentos compensatórios adotados pelos pacientes para manter sua independência funcional diante da fraqueza muscular. A literatura é escassa com relação ao estudo dos

movimentos compensatórios dos membros superiores de pacientes com distrofia muscular de Duchenne. Há concordância com relação à existência dos mesmos, mas não foram encontrados estudos que descrevam quais são eles, em quais segmentos podemos observá-los ou mesmo como é possível avaliá-los clinicamente. A fim de iniciar o estudo quantitativo dos movimentos compensatórios durante a realização de atividades funcionais dos membros superiores, desenvolvemos um quarto estudo. Este objetivou identificar os movimentos compensatórios de pacientes com distrofia muscular de Duchenne na comparação com os controles no movimento de levar uma colher à boca. Como resultados, encontramos o aumento da flexão do cotovelo e da cabeça e o aumento do tempo da tarefa tanto em pacientes no estágio inicial, quanto no estágio avançado da doença. Os resultados parciais deste trabalho foram apresentados recentemente em forma de pôster no *23rd International Annual of the World Muscle Society*. O resumo foi publicado em suplemento da Revista *Neuromuscular Disorders* (“*Bringing the spoon to the mouth or the mouth to the spoon? The analysis of compensatory movements of simulated feeding in Duchenne muscular dystrophy: a case-control study*”, Anexo 7). O estudo ainda não foi submetido à publicação e encontra-se na íntegra no corpo deste exemplar.

Esses quatro trabalhos contribuem para o aprimoramento da literatura a respeito do conhecimento das deficiências que interferem no controle motor e na função motora. Além disso, discute métodos sensíveis, confiáveis e específicos para avaliação dos membros superiores de pacientes com distrofia muscular.

INTRODUCTION

Duchenne muscular dystrophy is the most common type of muscular dystrophies^{1,2}. Becker muscular dystrophy is a less severe form, in which the quantity of dystrophin is reduced, but not absent³. Duchenne and Becker muscular dystrophy have a recessive character and are caused by abnormalities (mutation, deletion or duplication) of a gene located on the X chromosome. This gene encodes the protein dystrophin, which is part of the associated dystrophin-glycoprotein complex (cytoplasmic and membrane proteins that stabilize the muscle membrane)³. The absence or reduction in the dystrophin production results in muscle degeneration and progressive weakness⁴⁻⁶. The degeneration is caused by the disconnection of sarcomeres and tendon fibers, malformation of muscle fibers. These muscle structural changes affect the supporting role of dystrophin for the force transmission from the cytoskeleton to the extracellular matrix⁴⁻⁵.

The current prevalence is two in 10,000 boys between five and nine years old with Duchenne or Becker muscular dystrophy². The upper limbs weakness of boys with muscular dystrophy begins in the early stages and leads to functional deficits, even in ambulant patients. The evolution of weakness has a proximal-to-distal sequence. It begins in the proximal groups, progresses to the forearms and wrists, until the activity is restricted to hands and, eventually, fingers⁷⁻⁸. The functional limitations caused by the muscular weakness impact the ability of performing activities of daily living⁸.

The impact of upper limbs functional impairment in children with muscular dystrophy has been the subject of further literature investigation, due

to the increase in life expectancy to more than 30 years of age⁹. There is a need to evaluate the upper limbs motor function to monitor the clinical course and to establish appropriate therapeutic approaches¹⁰. There are few studies that describe recommendations for specific exercises or protocols for optimizing strength and endurance¹¹. The emergency of new therapeutic approaches increases the need of developing appropriate measurements in clinical trials¹²⁻¹³. However, upper limbs evaluation is complex and challenging, because patients present a variable combination of weakness, retractions and compensatory movements¹⁴⁻¹⁶. Appropriate measurements that incorporate the points cited and that may reflect the progression of the functional ability is a challenge for the health professionals¹⁵⁻¹⁶.

Mazzone et al.⁷ point out three requirements for an ideal instrument: to comprehend the whole spectrum of functional abilities, to bring up items of clinical relevance, and to have standardized tasks. Considering the instruments validated and used for assessing the upper limbs of patients with muscular dystrophy, the questionnaires Activity Limitations in Patients with Neuromuscular Disorders (ACTIVLIM), ABILHAND, Patient Reported Outcome Measure (PROM) and Upper Limb Short Questionnaire (ULSQ) may be indicated.

ACTIVLIM was developed and validated to characterize the clinical progression and to quantify the effects of treatments on the functional limitations of children and adults with neuromuscular diseases. However, it is not specific for upper limb assesment¹⁷. The ABILHAND was validated to measure the patient's perception of difficulty in performing daily manual activities. It was developed to evaluate children and adults with neuromuscular diseases¹⁸. The

PROM quantifies the functional impact on daily activities, as a complementary tool for the clinical observation of patients with Duchenne muscular dystrophy¹². The ULSQ assesses upper limb function, pain, and stiffness in boys and men with Duchenne muscular dystrophy¹⁹.

Regarding clinical tests validated and used for assessing the upper limbs of patients with muscular dystrophy, Muscular Dystrophy Functional Rating Scale, Brooke, Motor Function Measurement and Performance of Upper Limb are pointed. The Muscular Dystrophy Functional Rating Scale consists of mobility, activities of daily living, upper limbs impairment and function domains²⁰. The test assesses the manipulation of objects above the head, carrying objects, cleaning the table, writing, turning books pages of books, picking up and manipulating small objects, and manipulating small objects (upper limbs impairment and function domain). The other domains, however, are not restricted to upper limbs.

The Brooke scale was developed to classify the upper extremity functional level in muscular dystrophy from one to six, according to the motor involvement severity²¹. The Motor Function Measure assesses the motor function of patients with neuromuscular diseases. It quantifies proximal, axial and distal motor impairments. In distal motor function, six of seven items refer to wrist and hand functions²²⁻²⁴. However, this domain shows a floor effect and does not identify any function in patients with severe motor impairment²⁵.

The Performance of Upper Limb Test was created and validated for the evaluation of upper limb function of ambulatory and non-ambulatory boys with Duchenne muscular dystrophy. The items quantify the performance on daily life

activities in shoulder, elbow, and wrist domains and some of them involve timed performance^{10,26}.

Timed performance is an accurate measure for assessing functional ability and monitoring disease progression^{23,29}. The Jebsen-Taylor Test was developed to assess the upper limbs function by measuring the time required to perform shoulders, elbows and wrists movements. The Jebsen-Taylor Test evaluates writing, turning cards, using a spoon, picking up, stacking and transporting objects³⁰. The test was previously applied in boys with Duchenne muscular dystrophy³¹, but specific psychometric properties were not tested.

A recent study found correlations between timed performance (assessed by the Jebsen-Taylor Test), motor function (assessed by the Motor Function Measure) and muscle strength (assessed by the Manual Muscle Testing) of upper limbs of patients with muscular dystrophy³². Another study showed that the Performance of Upper Limb and Jebsen-Taylor Test scores are strongly correlated and represent a precise measure of assessing upper limb function³³.

Timed performance can reflect progression and functional independence. Increased times mean the need for assistance due to impaired upper limb function. Time can be influenced by compensatory movements, which are commonly adopted to maintain the functional independence.⁷ In order to assess all components of functional performance, evaluation protocols should include the observation of compensatory movements and their impact on timed performance^{11,34-35}.

PRIMEIRO ARTIGO**Hand function in Muscular Dystrophies: Relationship between Performance of Upper Limb and Jebsen-Taylor Tests**

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Abstract

The aim of this study was to investigate the relationship between Performance of Upper Limb (PUL) and Jebsen–Taylor Test (JTT) to assess and monitor upper limb function progression in patients with muscular dystrophy. Thirty patients diagnosed with Duchenne muscular dystrophy, limb-girdle muscular dystrophy, Becker muscular dystrophy, myotonic dystrophy Type 1, and fascioscapulohumeral dystrophy were submitted to the shoulder, elbow, and wrist domains of PUL, and to JTT subtests. Spearman tests investigated the relationships between PUL and JTT total scores and domains. Correlations were classified as strong ($r \geq 0.70$), moderate ($0.40 \leq r < 0.70$), or weak ($r \leq 0.40$). There were strong correlations between the PUL and JTT total scores ($r = -0.706$). Although JTT measures time and PUL provides kinesiology scores, these measures were related. Therefore, muscle synergies,

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Introduction

The number of non-ambulatory Muscular Dystrophy (MD) adult patients with upper limb (UL) dysfunction has been increasing (Bartels et al., 2011; Kohler et al., 2009). The development of specific therapeutic strategies in the past two decades have resulted in a longer survival, but also in a longer period of wheelchair dependency, during which UL function is essential. However, the specific UL impairment in patients with MD is still poorly described, partly due to a lack of accurate instruments with which to measure UL functioning.

The Performance of Upper Limb (PUL) Test represents one highly reliable outcome measure to evaluate the function of both ambulant and non-ambulant children and young adults with Duchenne Muscular Dystrophy (DMD). Test items, include performance tasks of activities of daily living that have been found to be capable of quantitatively assessing the three main levels of UL activity, including small distal movements (Mayhew et al, 2013; Pane et al, 2013).

Although timed performance can be an accurate means of measuring functional abilities in DMD (Beenaker, Maurits, Fock, Brouwer, Van der Houven, 2005; Martini et al., 2014) and possibly in other types of MD, PUL has very few timed items - “lifting light/ heavy cans” and “stacking light/ heavy cans” (Mayhew et al., 2013; Pane et al., 2013). Recent studies showed that timed performance and functional performance are correlated in lower limb functions of ambulant patients with DMD (Martini et al., 2014), but this relationship has not yet been investigated in UL functions.

The Jebsen-Taylor Test (JTT) was previously applied in boys with DMD (Hiller & Wade, 1992), but not in other MD types. JTT measures the time required to perform seven subtests that simulate everyday UL tasks. It represents a quantitative way of assessing distal and proximal UL functioning (Jebsen, Taylor, Trieckmann, Trotter & Howard, 1969). Timed performance reflects functional independence, since patients showing longer times are less functional and more likely to need assistance.

Accurate evaluation methods and continuously stimulating the best possible UL performance are essential to proper medical management of MD. UL functioning predicts higher levels of functional independence in wheelchair-dependent patients with MD (Henricson et al., 2013). Therefore, the relationship between kinesiological characteristics (measured by PUL) and timed performance (measured by JTT) in patients with MD merits study. We hypothesized that kinesiological characteristics and speed of performance would be related in patients with MD, and our study aimed to investigate this relationship through presumed correlations between PUL and JTT total and partial scores.

Method

This cross-sectional study was conducted prospectively and had prior ethical approval under process number 1.755.008 of the Ethics Committee of Clinics Hospital of Faculty of Medicine of University of São Paulo. Thirty patients diagnosed with various types of MD (DMD: 53.3%; Limb-Girdle Muscular Dystrophy: 26.7%, Becker Muscular Dystrophy: 10.0%, Myotonic Dystrophy type 1: 6.7% and Fascioscapulohumeral Dystrophy: 3.3%) composed a volunteer convenience sample for this study. Patients were aged

between 11 and 47 years (21.1 ± 7.9) and 28 were men. All participants were diagnosed by DNA analysis and gave written informed consent prior to their inclusion in the assessment protocol. Age, hand dominance and Vignos Scores (for staging MD progression) were collected and after that, volunteers were evaluated with PUL and JTT. Fifty percent of the patients (determined randomly) performed the PUL first, and then the JTT, and the other half of the sample performed the tests in the opposite order.

The analysis of hand dominance was performed by asking participants to engage in manipulation of everyday objects while researchers observed and recorded the preferred hand, according to the Oldfield Inventory (Oldfield, 1971). The Vignos score categorized the clinical staging of MD in the sample (Vignos, Spencer & Archibald, 1963).

PUL included 22 items, with an entry item to define the starting functional level, and 21 items subdivided into shoulder level (4 items), middle level (9 items) and distal level (8 items). The maximum possible score was 16 for shoulder level. Shoulder level assessed shoulder abduction and flexion. The maximum possible score was 34 for middle level. Middle (elbow) level evaluated hand to mouth, hand to table, weights moving, light/ heavy cans lifting and stacking, lid removing and tearing paper. The maximum possible score was 24 for distal level. Distal (wrist) level assessed tracing path, light pushing and turning, picking up coins, finger pointing, gripping and lifting movements. The total possible score on PUL was 74. Each item was scored between 0-6 or 0-1, according to individual performance (Mayhew et al., 2013; Pane et al., 2013).

JTT subtests were turning cards over; picking up small common objects; simulating feeding; stacking checkers; picking up large light objects (Jebsen,

Taylor, Triechmann, Trotter & Howard, 1969). The subtest “picking up heavy objects” was excluded, because most patients could not perform this task. The subtests were filmed and time was measured digitally. The camera was positioned laterally to face the patient, two meters from the dominant side.

All patients were assessed individually in a single evaluation session. They performed PUL and JTT unilateral tasks with the dominant upper limb. Patients were evaluated on sitting position, on their wheelchair or on a chair with back support, with correct positioning of hips, knees and ankles, flexed at approximately 90°.

The attempts that could not be performed were not excluded, because excluding them would result in lower total scores and would not reflect the difficulties of performing some tasks. Instead, for “could not perform” instances, the score was the highest value exhibited on the subtest (considering all scores of the sample) plus 20%.

Test data formed a non-normal distribution when tested by Kolmogorov-Smirnov. Accordingly, Spearman tests were run to investigate possible relationships between PUL and JTT total and partial scores. For JTT, the dominant UL timed performances were considered. In a previous study (Artilheiro, Sá, Fávero, Caromano & Voos, 2016), JTT dominant and non-dominant UL performances were strongly correlated. To interpret the results, correlation coefficients were classified as strong ($r \geq 0.70$), moderate ($0.40 \leq r < 0.70$) or weak ($r \leq 0.40$) (McGraw & Wong, 1992). Data were analyzed with Statistica version 13.0 (Statsoft, USA).

Results

Patient characteristics and partial and total scores of PUL and JTT are summarized in Table 1. The correlation between the total and partial scores of JTT and PUL can be observed in Table 2.

Tables 1 and 2

There were strong correlations between the PUL and JTT total scores ($r=-0.706$). PUL total score was strongly correlated to “turning cards over” ($r=-0.758$), “picking up small common objects” ($r=-0.817$), “simulating feeding” ($r=-0.781$), “stacking checkers” ($r=-0.782$), “picking up large light objects” ($r=-0.854$).

PUL shoulder dimension strongly correlated to “stacking checkers” ($r=-0.701$) and “picking up large light objects” ($r=-0.736$). PUL elbow dimension strongly correlated to “simulating feeding” ($r=-0.716$) “picking up large light objects” ($r=-0.751$). PUL wrist dimension strongly correlated to “turning cards over” ($r=-0.714$), “picking up small common objects” ($r=-0.820$), “simulating feeding” ($r=-0.763$), “stacking checkers” ($r=-0.760$), “picking up large light objects” ($r=-0.868$) and JTT total score ($r=-0.731$).

Discussion

The present study aimed to investigate the relationship between PUL and JTT. Kinesilogic characteristics and timed performance were correlated, as expected. Both tests assess and monitor UL function in patients with MD. PUL was developed specifically for DMD, but has been usable in other DM types.

The results showed strong negative correlations between PUL and JTT total scores, considering that high PUL scores and low JTT scores indicate a higher independence level. This means that the kinesiology scoring and the timed performance are related variables in UL functioning in patients with MD. However, in our sample, we found floor and ceiling effects of PUL total scores. Twelve patients scored between 64 and 74, while 18 scored between 18 and 39. As no patient scored between 40 and 60 on PUL total score, our data showed a non-normal distribution.

This variable sample included different types of MD with distinct motor involvement evidenced by variable Vignos Scores. The MD clinical population also shows high intragroup variability (between patients with the same DM type) and intergroup variability (between patients with distinct DM types) (Saada, Dib, Lipinki & Vassetzky, 2016). MD patients show variable muscle strength, because some have proximal to distal while others have distal to proximal progression, depending on MD type. However, recent studies reported no asymmetry of motor performance between upper limbs in patients with DMD (Artileiro, Sá, Fávero, Caromano & Voos, 2016; Janssen, Harlaar & de Groot, 2015; Troise et al., 2014).

PUL total score was strongly correlated to many items of JTT (“turning over cards”, “picking up small common objects”, “simulating feeding”, “stacking checkers”, “picking up large light objects”). This may be explained by the similar proximal muscle activation requirement to turn, grip and/ or transport the objects. Also, these tasks involve the proper recruitment and adjustment of elbow flexors and extensors and intrinsic fine hand movements. All JTT sub-items involve proximal, mid and distal level recruitment and control. The JTT

“writing” sub-item was the only item that did not correlate to PUL total and partial scores. The higher cognitive and distal coordination demands of JTT “writing” sub-item may explain the absence of strong correlations with PUL partial and total scores. The JTT “picking up large heavy objects” sub-item, which requires lifting and transporting approximately 453.6 grams, was excluded due to the impossibility of its execution by a majority of this population. This hypothesis was confirmed by “move weight on table” item of PUL elbow domain, which could not be excluded. Even lighter weights (100g or 200g) could not be moved, which resulted in increased partial and total PUL scores.

PUL shoulder dimension strongly correlated to JTT “stacking checkers” and “picking up large light objects” sub-items. PUL shoulder dimension evaluates shoulder abduction and flexion, which are required to anterior and lateral reaching and transporting the checkers and cans. Differently from elbow and wrist dimensions, PUL shoulder dimension does not evaluate functional tasks, only the strength to perform antigravity shoulder movements.

PUL elbow dimension strongly correlated to “simulating feeding”, “picking up large light objects”. JTT sub-item “simulating feeding” is similar to the PUL “hand to mouth” task, which is part of elbow level. Elbow flexors and extensors muscular strength is a key component in both tasks. Interestingly, only two PUL elbow dimension tasks showed strong correlations with JTT sub-items. Some items, as the “hand to table”, “move weight on table”, “lifting/ stacking light/ heavy cans” may count on shoulder compensatory movements when elbow movements do not have enough strength and amplitude. The subitems “lid removing” and “tearing paper” rely not only on elbow control, but also on distal fine movements.

PUL wrist dimension strongly correlated to “turning over cards”, “picking up small common objects”, “simulating feeding”, “stacking checkers”, “picking up large light objects” and JTT total score. The higher number of strong correlations between PUL wrist dimension and JTT sub-items shows the relevance of wrist and finger recruitment, control and dexterity in both PUL wrist dimension and JTT. Even patients showing more severe muscular weakness could perform, at least partially, the wrist domain tasks. Therefore, this domain can distinguish UL performance even in groups only with severe cases of MD. Besides, these sub-items can be performed by most patients with severe wrist compensatory movements.

The strong and moderate correlations between PUL and JTT total and partial scores show that UL timed performance and kinesiological scores are related in patients with MD. Two recent studies (Martini et al., 2014, 2015) showed that lower limbs motor functions and timed performance were correlated in ambulant patients with DMD. The present study expands this knowledge, showing that such correlations are also found in wheelchair dependent patients and in a sample with not only DMD, but also other types of MD. This study showed that PUL and JTT scores were correlated. Therefore, the muscle synergies, which control the compensatory movements and motor functions involving mainly shoulder, elbow, wrist and finger movements, were correlated to timed performance in patients with MD.

As a limitation of this study, some MD types had a low number of patients in our sample. Therefore, future studies should include and examine separately patients with different MD diagnoses.

Based on these findings, physical/ occupational therapists should assess timed performance when a patient's complaint is related to slow performance of daily life activities (feeding, clothing, hygiene etc) and/or frequent assistance from parents or caregivers to help patients take less time. Use of the JTT can be helpful in these instances. When patients report muscle pain and/or severe scoliosis or the therapist establishes distal, medium or proximal priority, evaluating the kinesiologic characteristics with the PUL test is recommended. Since PUL and JTT are correlated, the use of either test may help predict performance on the other, perhaps avoiding exposing patients to excessive physical effort testing and offering therapists faster, more specific assessment protocols.

References

- Artilheiro, M. C., Sá, C. S. C., Fávero, F. M., Caromano, F. A., & Voos, M. C. (2016). Hand function in muscular dystrophies: relationship between performance of upper limb and jebsen-taylor tests. *Brazilian Journal of Medical and Biological Research* (submitted).
- Bartels, B., Pangalila, R. F., Bergen, M. P, Cobben, N. A. M., Stam, H. J., & Roebroek, M. E. (2011). Upper limb function in adults with duchenne muscular dystrophy. *Journal of Rehabilitation Medicine*, 43, 12–17.
- Beenakker, E. A., Maurits, N. M., Fock, J. M., Brouwer, O. F., & Van der Hoeven, J. H. (2005). Functional ability and muscle force in healthy children and

ambulant Duchenne muscular dystrophy patients. *European Journal of Paediatric Neurology*, 9, 387–393.

Henricson, E. K., Abresch, R. T., Cnaan, A., Hu, F., Duong, T., Arrieta, A.,...CINRG Investigators. (2013). The Cooperative International Neuromuscular Research Group Duchenne natural history study: glucocorticoid treatment preserves clinically meaningful functional milestones and reduces rate of disease progression as measured by manual muscle testing and other commonly used clinical trial outcome measures. *Muscle & Nerve*, 48(1), 55–67.

Hiller, L. B., & Wade, C. K. (1992). Upper extremity functional assessment scales in children with Duchenne muscular dystrophy: a comparison. *Archives of Physical Medicine and Rehabilitation*, 73, 527–534.

Janssen, M. M., Harlaar, J., & de Groot, I. J. (2015). Surface EMG to assess arm function in boys with DMD: a pilot study. *Journal of Electromyography and Kinesiology*, 25(2), 323–328.

Jebsen, R. H., Taylor, N., Trieckmann, R. B., Trotter, M. J., & Howard, L. A. (1969). An objective and standardized test of hand function. *Archives of Physical Medicine and Rehabilitation*, 50, 311–319.

Kohler, M., Clarenbach, C. F., Bahler, C., Brack, T., Russi, E. W., & Bloch, K. E. (2009). Disability and survival in Duchenne muscular dystrophy. *Journal of Neurology, Neurosurgery & Psychiatry*, 80, 320–325.

Martini, J., Hukuda, M. E., Caromano, F. A., Favero, F. M., Fu, C., & Voos, M. C. (2014). The clinical relevance of timed motor performance in children with Duchenne muscular dystrophy. *Physiotherapy Theory and Practice*, 24, 1–9.

Martini, J., Voos, M. C., Hukuda, M. E., Resende, M. B. D., & Caromano, F. A. (2014). Compensatory movements during functional activities in ambulatory children with Duchenne muscular dystrophy. *Arquivos de Neuropsiquiatria*, 72(1), 5-11.

Mayhew, A., Mazzone, E. S., Eagle, M., Duong, T., Ash, M., Decostre, V.,...Performance of the Upper Limb Working Group. (2013). Development of the performance of the upper limb module for Duchenne muscular dystrophy. *Developmental Medicine and Child Neurology*, 55,1038–1045.

McGraw, K. O., & Wong, S. P. (1992). A common language effect-size statistic. *Psychological Bulletin*, 111, 361–365.

Oldfield, R. C. (1971). The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychologia*, 9(1), 97–113.

Pane, M., Mazzone, E. S., Fanelli, L., De Sanctis, R., Bianco, F., Sivo, S.,...Mercuri, E. (2013). Reliability of the Performance of Upper Limb

assessment in Duchenne muscular dystrophy. *Neuromuscular Disorders*, 24(3), 201–205.

Saada, Y. B., Dib, C., Lipinki, M. & Vassetzky, Y. S. (2016). Genome- and Cell-Based Strategies in Therapy of Muscular Dystrophies. *Biochemistry Biokhimiia*, 81(7), 678–690.

Troise, D., Yoneyama, S. M., Resende, M. B. D., Reed, U., Xavier, G. F., & Hasue, R. (2014). The influence of visual and tactile perception on hand control in children with Duchenne Muscular Dystrophy. *Developmental Medicine and Child Neurology*, 56(9), 882–887.

Vignos, P. J. Jr., Spencer, G. E. Jr., & Archibald, K. C. (1963). Management progressive muscular dystrophy of childhood. *JAMA*, 184, 89–96.

Table 1—Patients characteristics and median, minimum and maximum scores of Performance of Upper Limb and Jebsen-Taylor Test

	Diagnosis/ Vignos	Gender/ Age	PUL Shoulder	PUL Elbow	PUL Wrist	PUL Total	JTT 1	JTT 2	JTT 3	JTT 4	JTT 5	JTT 6	JTT Total
1	MD1/1	M/34	16	36	24	76	21.45	5.67	5.62	7.45	1.29	4.14	45.62
2	DMD/1	M/13	16	36	24	76	28.85	3.19	6.28	11.16	1.87	3.28	54.63
3	DMD/8	M/16	2	13	16	31	34.47	5.41	12.65	21.18	3.75	11.06	88.52
4	LGMD/5	F/22	0	13	16	29	20.78	6.22	11.68	24.22	2.53	12.69	78.12
5	DMD/8	M/20	0	13	17	30	23.28	15.09	32.75	23.75	9.38	15.53	119.78
6	DMD/8	M/16	0	13	15	28	28.10	6.50	17.19	59.21	9.40	14.34	134.74
7	BMD/2	M/28	12	36	25	73	18.15	5.78	6.61	8.29	2.40	4.44	45.67
8	LGMD/8	M/47	0	12	9	21	49.56	18.47	43.75	214.03	9.28	28.41	363.50
9	DMD/7	M/17	0	12	12	24	66.22	11.72	34.66	133.56	10.21	24.65	281.02
10	LGMD/8	M/23	0	16	9	25	21.81	23.31	78.56	101.66	45.91	83.31	354.56
11	DMD/8	M/18	0	14	14	28	31.81	6.53	17.06	35.47	10.25	8.84	109.96
12	DMD/8	M/25	0	21	18	39	33.93	5.38	7.40	8.47	3.56	6.50	65.24
13	LGMD/5	M/34	8	35	22	65	13.60	4.65	6.47	7.25	2.32	5.03	39.32
14	LGMD/1	M/18	15	35	23	73	22.30	4.60	5.84	9.59	1.66	4.25	48.24
15	DMD/7	M/24	0	12	14	26	131.63	13.60	14.54	14.87	5.63	26.06	206.33
16	DMD/1	M/11	15	36	24	75	66.85	9.09	15.66	16.12	7.84	10.94	126.50
17	LGMD/7	M/29	9	34	23	66	22.75	6.68	13.63	18.10	5.69	8.94	75.79
18	DMD/8	M/20	0	11	12	23	65.22	43.28	52.53	129.28	34.43	37.28	362.02
19	DMD/2	M/13	16	36	24	76	21.56	3.60	5.06	9.78	2.31	4.22	46.53
20	LGMD/8	M/23	0	10	13	23	16.89	15.84	35.12	61.81	12.25	22.81	164.72
21	BMD/6	M/25	13	33	23	69	22.13	4.31	6.81	9.62	3.03	4.56	50.46
22	DMD/3	M/13	16	36	24	76	66.87	5.29	5.84	11.38	5.28	6.87	101.53
23	DMD/7	M/15	1	13	12	26	15.60	8.81	12.13	14.68	5.72	13.22	70.16
24	FSH/7	M/19	16	34	24	74	12.72	6.93	7.50	8.72	2.03	5.38	43.28
25	DMD/8	M/16	4	15	12	31	151.37	14.16	78.96	27.97	8.75	32.07	313.28
26	DMD/7	M/23	0	11	7	18	32.69	30.13	68.66	107.03	20.21	29.91	288.63
27	SMD/1	F/11	16	33	24	73	89.99	6.31	9.66	19.66	4.59	6.22	136.43
28	DMD/7	M/21	0	11	20	31	16.63	8.03	9.59	15.87	4.75	6.53	61.40
29	LGMD/7	M/26	0	14	20	34	30.69	8.78	11.69	18.44	5.94	12.14	87.68

30	DMD/7	M/13	0	16	19	35	151.37	12.41	14.56	39.38	6.50	14.28	238.50
-	7 (1-8)	28 M/ 2 F 20 (11-47)	0.5 (0-16)	15.5 (10-36)	18.5 (7-25)	32.5 (18-76)	28.48 (12.72- 151.37)	6.8 (3.19-43.28)	12.39 (5.06-78.96)	18.27 (7.25- 214.03)	5.66 1.29-45.91)	11 28-83.31)	95.02 (39.32- 363.5)

M: male; F: female; MD1: Myotonic Dystrophy type 1; DMD: Duchenne Muscular Dystrophy; LGMD: Limb-girdle Muscular Dystrophy; BMD: Becker Muscular Dystrophy; FSH: Fascioscapulohumeral Dystrophy; PUL: Performance of Upper Limb; JTT: Jebsen-Taylor Test.

Table 2 – Spearman's correlation coefficients (r) of Performance of Upper Limb domains and total score and Jebsen-Taylor Test subitems and total score

	PUL Shoulder	PUL Elbow	PUL Wrist	PUL Total	JTT 1	JTT 2	JTT 3	JTT 4	JTT 5	JTT 6	JTT Total
PUL Shoulder	-	0.825	0.790	0.861	0.143	0.644	0.685	0.666	0.700	0.736	-0.587
PUL Elbow	0.825	-	0.824	0.913	0.111	0.688	0.698	0.716	0.658	0.751	-0.614
PUL Wrist	0.790	0.824	-	0.946	0.205	0.714	0.820	0.763	0.760	0.868	-0.730
PUL Total	0.861	0.913	0.946	-	0.115	0.758	0.817	0.780	0.782	0.853	-0.706
JTT 1	-0.143	-0.111	-0.205	-0.115	-	0.269	0.381	0.432	0.371	0.399	0.672
JTT 2	-0.644	-0.688	-0.714	-0.758	0.269	-	0.886	0.745	0.826	0.887	0.793
JTT 3	-0.685	-0.698	-0.820	-0.817	0.381	0.886	-	0.877	0.913	0.927	0.876
JTT 4	-0.666	-0.716	-0.763	-0.780	0.432	0.745	0.877	-	0.863	0.841	0.899
JTT 5	-0.700	-0.658	-0.760	-0.782	0.371	0.826	0.913	0.863	-	0.871	0.857
JTT 6	-0.736	-0.751	-0.868	-0.853	0.399	0.887	0.927	0.841	0.871	-	0.891
JTT Total	-0.587	-0.614	-0.730	-0.706	0.672	0.793	0.876	0.899	0.857	0.891	-

PUL: Performance of upper limb; JTT: Jebsen-Taylor Test; all moderate and strong correlations exhibited $p < 0.001$.

SEGUNDO ARTIGO

Patients with Duchenne and Becker muscular dystrophies are not more asymmetrical than healthy controls on timed performance of upper limb tasks

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Patients with Duchenne and Becker muscular dystrophies are not more asymmetrical than healthy controls on timed performance of upper limb tasks

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Abstract

This study aimed to investigate possible asymmetries and relationships between performance of dominant and non-dominant upper limbs (UL) in patients with Duchenne and Becker muscular dystrophies (DMD/BMD), to compare UL performance of patients and healthy subjects and to investigate the relationship between timed performance of UL and age, motor function and muscle strength in DMD/BMD patients. Sixteen patients with DMD and 3 with BMD were evaluated with Jebsen-Taylor Test (timed performance), Vignos scale and Dimension 3 of Motor Function Measure (motor function), and Medical Research Council scale (muscle strength) on a single session. ANOVA showed no asymmetry between dominant and non-dominant UL, except in the writing subtest, in patients and in healthy controls. There were relationships between dominant and non-dominant UL performances. Correlations between timed performance, motor function and muscle strength were found, but age was not correlated with these variables. These findings may reduce the assessment time, prevent fatigue and provide more accurate clinical reasoning involving UL in DMD/BMD treatment.

Key words: Duchenne muscular dystrophy; Upper extremity; Evaluation; Physical therapy

Introduction

The recent increase of life expectancy of patients with Duchenne and Becker muscular dystrophies (DMD and BMD) represents more patients living with impaired upper limb (UL) function for longer times (1). DMD and BMD are related conditions that affect skeletal muscles. They occur almost exclusively in males and have similar signs and symptoms that are caused by different mutations in the same gene. Because DMD and BMD result from faulty or missing dystrophin, these conditions are classified as dystrophinopathies.

DMD and BMD may differ in severity, age of onset and rate of progression. In DMD, muscle weakness tends to decrease faster. DMD and BMD together affect 1 in 3500 to 5000 newborn males worldwide. Both show proximal-to-distal progression, with relative sparing of distal hand function (2). Losses of hand and wrist functions occur mainly in advanced stages (3,4). Due to the progressive nature of DMD/BMD, upper extremity weakness and limitations impair the ability of performing daily life activities, including eating, bathing, and tooth brushing (2,5).

Assessing UL function in non-ambulant patients with DMD/BMD is challenging, because of the combination of severe weakness, contractures, clinical heterogeneity and varied compensatory strategies (from patient to patient and even from limb to limb) (1). Janssen et al. (6) investigated the differences between dominant and non-dominant UL activity of shoulder and elbow muscles of 5 patients with DMD. The patients performed single movements of these joints and the non-standardized tasks of reaching forward, touching the contralateral shoulder, combing hair and bringing the hand to the

mouth. They found no significant differences in shoulder and elbow muscle recruitment between ULs (6). However, the activities of daily living were just simulated, without real goal or use of objects, which may have interfered on the results. Although non-dominant UL performance seems to be poorer than dominant limb performance, no studies compared the performance of patients with DMD/BMD in real and goal-directed functional activities (7).

Considering that scoliosis is frequent in DMD/BMD, the convexity could be related to UL asymmetry (3). Additionally, a better understanding about UL performance and possible symmetries or asymmetries between dominant and non-dominant limbs could optimize evaluation and clinical reasoning for interventions involving UL function in DMD/BMD (7).

This study aimed to investigate possible differences and relationships between the performances of dominant and non-dominant ULs in daily living, goal-directed activities in patients with DMD/BMD. We hypothesized that dominant and non-dominant ULs would exhibit significantly different performances. Also, we aimed to compare patients with normative data from the literature of gender- and age-matched healthy controls. We hypothesized that UL asymmetry would be higher in patients with DMD/BMD than in healthy controls, because patients show many compensatory movements.

As a secondary objective, we aimed to investigate the relationship of UL timed performance and age, motor function and muscle strength in DMD/BMD patients. We hypothesized that these variables would be related in DMD/BMD patients and that the asymmetry would be less evident in initial DMD/BMD (younger patients) than in severe cases (older patients).

Material and Methods

The study was approved by the Federal University of São Paulo Ethics Committee (process No. 132-193). This is a prospective observational study with cross-sectional design.

Subjects

All patients from the Brazilian Association of Muscular Dystrophy (ABDIM) with non-normal levels of dystrophin detected by DNA analysis were recruited to participate. The inclusion criterion was the confirmation of absence (in DMD) or decreased levels (in BMD) of dystrophin, which is a biomarker of a genetic error on Xp21 (8). Forty-three patients gave informed consent to participate.

Ten patients were excluded due to time unavailability. Seven patients were excluded because they could not grasp objects. Seven patients were excluded due to difficulty understanding the tasks, caused by severe cognitive impairment, detected by the Mini-Mental State Examination (MMSE) (9). In a previous pilot study, we observed that a cut-off of ten points (instead of eighteen) could be considered for these patients, because they could perform all Jebsen-Taylor and Motor Function Measure tasks. All patients included in the study were able to understand the tasks (10).

The patients, parents or legal guardians signed the informed consent form prior to participation. Sixteen patients with DMD (aged 16.8 ± 3.9 years) and 3 with BMD (aged 26.0 ± 1.7 years) were evaluated. All patients scored 7 or 8 on the Vignos Scale (11) and used wrist orthosis during the night.

Procedures

Lower extremity function was classified by the Vignos Scale (11). The scores range from 1 to 10, with 1 meaning that the subject can walk and climb stairs without assistance, and 10 meaning that the subject is confined to a bed.

Upper extremity function was classified by the Brooke Scale (12). This scale ranges from 0 to 6, with 1 meaning that the patient is able to abduct the shoulder in 180 degrees and 6 meaning that the patient has no useful function of the UL.

Dominance was determined by asking and observing the preferred hand during the manipulation of everyday objects, such as scissors, comb, toothbrush and pencil (13).

Muscle strength of shoulders (flexors, extensors, abductors, adductors, internal and external rotators), elbows (flexors, extensors, supinators and pronators) and wrists (flexors and extensors) were tested by the Medical Research Council (MRC) Scale (14). To test muscle groups, manual resistance was applied with the patient lying on dorsal, ventral, and lateral decubitus, and on sitting position. The score was graded from 0 to 5, with 0 indicating no muscle contraction and 5 indicating normal strength (15). We adopted the MRC index (14) to calculate the percentage of muscle strength according to proximal (shoulder) or distal (elbow and wrist) location.

Spinal deformity was evaluated by asking the patient to lean forward with support if necessary (16). The side (right or left) and curve convexity were registered.

All patients were assessed with the Jebsen-Taylor Test (JTT) (17,18) and Dimension 3 of Motor Function Measure (MFM D3) (19–21). Each patient was positioned on his own wheelchair or in a height-adjustable chair, which allowed the correct positioning of hips, knees and ankles, flexed at approximately 90°. A table with adjustable height was used. Each subtest was conducted after making sure the patient had understood the task.

JTT has seven subtests (1: writing; 2: turning over cards; 3: picking up small common objects; 4: simulating feeding; 5: stacking checkers; 6: picking up large light objects; 7: picking up large heavy objects). All subtests have gender- and age-matched normative values for people between 15 and 25 years old in order to compare timed performances (22). Subtest 7 was excluded because patients with DMD/BMD have difficulty carrying heavy objects. Subtests 1, 2, 3, 4, 5, and 6 were performed in sequence, first with the non-dominant UL and then with the dominant UL, according to Jebsen-Taylor standard instructions (17). The time of all attempts was measured in seconds (s) using a stopwatch (17,18). When a patient was not able to complete a JTT subtest due to motor difficulties, the score was registered as the highest time on the subtest plus 20%.

MFM D3 consists of seven items to evaluate distal motor function. The scoring of each item uses a 4-point scale (from 0 to 3). Zero means that the patient cannot initiate the task or cannot maintain the starting position and 3 means the patient is able to complete the task with the standard pattern. The total score is reported as a percentage of the maximum possible score (19–21).

Data analysis

Data showed homoscedasticity (tested by Levene Test) and normal distribution (tested by Kolmogorov-Smirnov Test). Analyses of variance (two-way ANOVAs) compared dominant and non-dominant UL timed performances. When *post hoc* analyses were necessary, Tukey tests were run. The relationships between dominant and non-dominant UL performances and JTT, MFM D3 and MRC scores were tested by Pearson correlation tests. The correlation coefficients (r) were considered strong when $r \geq 0.70$ and moderate when $0.40 \leq r < 0.70$ (23).

In order to investigate UL asymmetry in JTT subtests, patients were compared to normative data. A dominance index (the mean time of the dominant UL divided by the mean time of the non-dominant UL) was calculated, which represents UL symmetry. Values near zero indicate UL asymmetry and values near one indicate UL symmetry. The comparison between two proportions was done with the chi-square test. The relationships between the dominance indexes and age were tested by Spearman correlation tests (23).

Statistical analysis was performed using the Statistica software version 13.0 (Statsoft, USA). The level of significance was set at 5%.

Results

Clinical characteristics

Sample characteristics are displayed in Table 1. Vignos scores ranged from 1 to 8 and Brooke scores ranged from 1 to 5. About 90% (n=17) of patients exhibited right UL dominance. The median of the percentages of proximal muscle strength and distal muscle strength were 50 and 66%, respectively. Most patients (n=10; 52.6%) showed thoracolumbar scoliosis, 5 patients (26.3%) showed lumbar scoliosis, 1 (5.3%) showed thoracic scoliosis and 3 (15.8%) did not show scoliosis. All patients understood and performed all tests without referring pain, fatigue or discomfort.

Comparison between dominant and non-dominant UL performance on JTT subtests

Repeated measures ANOVA showed an effect of JTT subtest ($F_{5,90}=17.167$; $P<0.001$; $ES=0.488$), an effect of UL ($F_{1,18}=15.444$; $P<0.001$; $ES=0.462$) and an interaction between subtest and UL ($F_{5,90}=10.433$; $P<0.001$; $ES=0.367$). *Post hoc* Tukey tests showed a significant difference between non-dominant and dominant UL only in subtest 1 ($P<0.001$; Figure 1).

No significant differences between patients and controls (normative data) were found in the dominance indexes of JTT subtests (Table 2).

Correlations between dominant and non-dominant UL performances on JTT

Strong positive correlations were found between non-dominant and dominant UL in all JTT subtests (Table 3). Many strong relationships were found between the performances of dominant and non-dominant UL in subtests 2, 3, 4, 5, and 6 (Table 3).

Correlation between muscle strength (MRC), JTT and MFM scores

Vignos score strongly correlated to proximal ($r=-0.847$; $P<0.001$) and distal muscle strength ($r=-0.790$; $P<0.001$). Proximal muscle strength strongly correlated to subtest 6 performed by non-dominant UL ($r=-0.767$; $P<0.001$) and to distal muscle strength ($r=0.777$; $P<0.001$). Distal muscle strength strongly correlated to subtests 3 and 6, performed by the dominant UL ($r=-0.717$ and $r=-0.709$, respectively; $P<0.001$). MFM D3 strongly correlated to subtest 6, performed by the dominant UL ($r=-0.709$; $P<0.001$) (Table 4).

Discussion

The present study investigated possible differences and relationships between the performances of dominant and non-dominant ULs on daily life, goal-directed activities of patients with DMD/BMD with normative data of healthy controls. The clinical heterogeneity of our sample was expected. We believe this phenotypic variability is important to represent the whole spectrum of UL dysfunctions observed in DMD/DMB forms and stages.

First, we hypothesized that dominant and non-dominant ULs would exhibit significantly different performances. Our results showed that this occurred only with JTT subtest 1, which was a writing task. The writing subtest was significantly faster with the dominant UL in patients and controls. This ability involves much more unilateral coordination than the other tasks (22). This difference between UL performances was not observed in the other five JTT subtests (2: turning over cards; 3: picking up small common objects; 4: simulating feeding; 5: stacking checkers; 6: picking up large light objects).

UL performance of DMD patients has been studied by Janssen et al. (6). They assessed the maximal voluntary isometric contraction of biceps brachii, anterior deltoid and lateral deltoid muscles, single joint movements of elbow flexion/extension and pronation/supination, shoulder abduction/ adduction, flexion/extension, internal/external rotation and the simulation of reaching forward, touching contralateral shoulder, combing hair and bringing the hand to the mouth (6). No significant differences were found between left and right UL movements considering muscle activation. However, the authors worked with open-loop situations that have much higher predictability than the present study. In our study, patients had to deal with closed-loop tasks (24). Considering subtest 4 (simulating feeding) as an example, the task requires motor reprogramming during the attempts of holding a spoon, picking up the beans, transporting and depositing them in a bowl. The result of action is continually considered for movement corrections during the task. JTT protocol involves real goals instead of only simulating the tasks, which results in higher muscular demand (25).

Second, we hypothesized that UL asymmetry would be less evident in initial cases of dystrophinopathies (younger patients) and more evident in severe cases (older patients). This hypothesis was not confirmed by our results. Although we included wide ranges for age and Vignos scores, no correlations between age, dominance index and timed performance was observed.

We also hypothesized that UL asymmetry would be higher in patients with DMD/BMD than in healthy controls, due to the compensatory movements employed to perform functional tasks. The dominance indexes showed that patients with DMD/BMD are not more asymmetrical than gender- and age-matched healthy controls. The dominance index was developed to elucidate how much slower would be the non-dominant limb than the dominant limb, and therefore, how asymmetric patients would be. The indexes close to 1 represent the absence of asymmetry in timed performance of UL of patients and healthy controls. Furthermore, the dominance index was not correlated with age or Vignos score, showing that it is independent of disease stage.

We observed that the performances of ULs were consistently correlated in patients. This relationship can be explained by the existence of motor equivalence, which is part of the central motor program theory (26). This theory states that limbs move together, as a unit, due to a unique central motor program, which controls all action parameters. Besides, one limb activity can prevail over the other. Therefore, the non-dominant can move to assist the dominant UL. Interestingly, we found the same pattern in patients with DMD/DMB.

We found many correlations between proximal and distal muscle strength and timed performance on JTT tasks. Lower proximal and distal muscle strength denotes higher times on JTT subtests. Also, JTT times of dominant and non-dominant ULs were correlated to each other and many of them were also correlated to MFM. JTT and MFM represent different ways of assessing UL function in DMD/BMD patients. Dimension 3 of MFM assesses the quality of distal UL movements, with only one timed task, and JTT assesses timed performance, but both tests require dexterity and represent motor function. Nunes et al. (2016) found a relationship between motor function and muscular strength measured by MFM and manual testing, respectively, in patients with DMD. The present study expands this knowledge, establishing the relationship between timed performance, motor function and muscular strength.

Scoliosis is usually secondary to muscle weakness and part of the natural history of DMD (27), with higher prevalence among more severe cases (28,29). The impact of scoliosis on UL function was poorly studied in the literature. Patients with good trunk stability can perform UL functions without support. Contrarily, patients with poor trunk stability need trunk support to perform UL tasks. A recent study (30) related the occurrence of scoliosis with poor UL function, due to the impairment of sitting balance. Therefore, reduced sitting balance has a negative influence on UL function (31,32). Besides, it seems that the side scoliosis is not related to UL dominance, although the non-dominant UL is more frequently observed as a support for the non-aligned trunk side. Scoliosis convexity did not coincide with UL dominance.

Cognitive impairment is common in boys with DMD/BMD (33). Therefore, feasible tests must be developed, considering this characteristic. In a previous pilot study (10), we verified that in patients aged 10 to 30 years, MMSE scores were correlated to scores of cognitive tests (verbal fluency, clock drawing, and digits - direct and inverse orders). That study showed that patients scoring 11 or higher in MMSE can perform all JTT and MFM subtests. We observed that cognitive impairment did not interfere with the comprehension of simple verbal commands. However, lower MMSE scores were obtained in individuals with lower motor performance on JTT and MFM. Patients with better cognitive function may select more efficient motor synergies to overcome muscular weakness.

The findings provide relevant information for clinical practice. First, this assessment battery did not show any symptoms of overuse of dominant UL or disuse of non-dominant UL and can be considered safe. Second, as dominant and non-dominant UL performances were correlated, the assessment protocol can be performed with only one UL, to eliminate redundancy. It may reduce assessment time and prevent fatigue. Third, this assessment protocol evaluates two different and relevant features of UL function: timed performance (JTT) and UL movements (MFM D3).

Future studies could describe the compensatory movements performed by patients with DMD/BMD, not only on limbs, but also trunk movements, which contribute to a better performance of UL functions. Trunk movements may have helped on some JTT tasks. Besides, the investigation between limbs and trunk strength, and timed performed data may add information for better understand

the performance of patients with DMD/BMD. These findings will optimize clinical intervention approaches to preserve muscle activation and UL function.

In conclusion, UL performance was only asymmetrical in the writing test, but not in other UL tasks. Dominant and non-dominant UL performances were correlated on daily life, goal-directed activities of patients with DMD/BMD. Gender- and age-matched healthy controls were not more asymmetrical than patients. Asymmetry was not more evident in more severe cases (older patients) than in less severe cases (younger patients). Correlations between timed performance, motor function and muscle strength were found, but age was not correlated to these variables.

References

1. Janssen MM, Bergsma A, Geurts AC, de Groot IJ. Patterns of decline in upper limb function of boys and men with DMD: an international survey. *J Neurol* 2014; 261: 1269–1288.
2. Alemdaroğlu I, Karaduman A, Yilmaz ÖT, Topaloğlu H. Different types of upper extremity exercise training in Duchenne muscular dystrophy: effects on functional performance, strength, endurance, and ambulation. *Muscle Nerve* 2015; 51: 697–705.
3. McDonald CM, Abresch RT, Carter GT, Fowler WM Jr, Johnson ER, Kilmer DD et al. Profiles of neuromuscular diseases. Duchenne muscular dystrophy. *Am J Phys Med Rehabil* 1995; 74 (5 Suppl): S70–S92.
4. Henricson EK, Abresch RT, Cnaan A, Hu F, Duong T, Arrieta A et al. The cooperative international neuromuscular research group Duchenne natural

history study: glucocorticoid treatment preserves clinically meaningful functional milestones and reduces rate of disease progression as measured by manual muscle testing and other commonly used clinical trial outcome measures. *Muscle Nerve* 2013; 48: 55–67.

5. Servais L, Deconinck N, Moraux A, Benali M, Canal A, Van Parys F et al. Innovative methods to assess upper limb strength and function in non-ambulant Duchenne patients. *Neuromuscul Disord* 2013; 23: 139–148.

6. Janssen MM, Harlaar J, de Groot IJ. Surface EMG to assess arm function in boys with DMD: a pilot study. *J Electromyogr Kinesiol* 2015; 25: 323–328.

7. Connolly AM, Malkus EC, Mendell JR, Flanigan KM, Miller JP, Schierbecker JR et al. Outcome reliability in non-ambulatory boys/men with Duchenne muscular dystrophy. *Muscle Nerve* 2015; 51: 522–532.

8. Juan-Mateu J, Gallano P, Trujillo-Tiebas MJ, Grupo AEGH/CIBERER. Recommendations of good practices for the genetic diagnosis of Duchenne and Becker muscular dystrophies. *Med Clin* 2012; 139: 307–312.

9. Folstein MF, Folstein SE, McHugh PR. Mini-Mental State: a practical method for grading the cognitive state of patients for clinician. *J Psychiatr Res* 1975; 12: 189–198.

10. Voos M, Favero F, Dias K, Artiheiro M, Oliveira A, Caromano F. Dissociation between motor and cognitive skills in patients with Duchenne muscular dystrophy. *Neuromuscul Disord* 2015; 25 (Suppl 2): S306.

11. Vignos PJ Jr, Spencer GE Jr, Archibald KC. Management progressive muscular dystrophy of childhood. *JAMA* 1963; 184: 89–96.
12. Brooke MH, Griggs RC, Mendell JR, Fenichel GM, Shumate JB, Pellegrino RJ. Clinical trial in duchenne dystrophy: I design of protocol. *Muscle Nerve* 1981; 4: 186–197.
13. Oldfield RC. The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychol* 1971; 9: 97–113.
14. Scott OM, Hyde SA, Goddard C, Dubowitz V. Quantification of muscle function in children: a prospective study in Duchenne muscular dystrophy. *Muscle Nerve* 1982; 5: 291–301.
15. Nunes MF, Hukuda ME, Favero FM, Voos MC, Oliveira AB, Caromano FC. Relationship between muscle strength and motor function in Duchenne muscular dystrophy. *Arq Neuropsiquiatr* 2016; 74: 530–535.
16. Hsu JD, Quinlivan R. Scoliosis in Duchenne muscular dystrophy. *Neuromuscul Disord* 2013; 23: 611–617.
17. Jebsen RH, Taylor N, Trieckmann RB, Trotter MJ, Howard LA. An objective and standardized test of hand function. *Arch Phys Med Rehabil* 1969; 50: 311–319.
18. Ferreiro KN, Santos RL, Conforto AB. Psychometric properties of the Portuguese version of the Jebsen-Taylor test for adults with mild hemiparesis. *Braz J Phys Ther* 2010; 14: 377–381.

19. Bérard C, Payan C, Hodgkinson I, Fermanian J. A motor function measure scale for neuromuscular diseases. Construction and validation study. *Neuromuscular Disord* 2005; 15: 463–470.
20. Bérard C, Payan C, Fermanian J, Girardot F, Grouped'Etude MFM. A motor function measurement scale for neuromuscular disease - description and validation study. *Rev Neurol* 2006; 162: 485–493.
21. Iwabe C, Miranda-Pfeilsticker BH, Nucci A. Medida da função motora: versão da escala para o português e estudo de confiabilidade. *Rev Bras Fisioter* 2008; 12: 417–424.
22. Sarafriz Z, Vahedi Z. Hand function related to age and gender. *Iran Rehab J* 2008; 6: 10–15.
23. McGraw KO, Wong SP. A common language effect-size statistic. *Psychol Bull* 1192; 111: 361–365.
24. Adams JA. A closed-loop theory of motor learning. *J Motor Behav* 1971; 3: 111–150.
25. McKay JL, Ting LH. Optimization of muscle activity for task-level goals predicts complex changes in limb forces across biomechanical contexts. *PLoS Comput Biol* 2012; 8: 1–17.
26. Schmidt RA, Lee TD. Motor control and learning: a behavioral emphasis. 5th edn. Champaign: Human Kinetics. 2011

27. Thong M-K, RajzBazlin RI, Wong K-T. Diagnosis and management of Duchenne muscular dystrophy in a developing country over a 10-year period. *Dev Med Child Neurol* 2005; 47: 474–477.
28. Boulay C, Finidori G. Aspects fonctionnel set orthopédiques des dystrophinopathies. *Arch Pédiatr* 2015; 22: 1242–1250.
29. Scannell BP, Yaszay B, Bartley CE, Newton PO, Mubarak SJ. Surgical correction of scoliosis in patients with duchenne muscular dystrophy: 30-year experience. *J Pediatr Orthop* 2016. [Epub ahead of print].
30. Janssen MM, Hendriks JC, Geurts AC, de Groot IJ. Variables associated with upper extremity function in patients with Duchenne muscular dystrophy. *J Neurol* 2016; 263: 1810–1818.
31. Chen CL, Yeung KT, Bih LI, Wang CH, Chen MI, Chien JC. The relationship between sitting stability and functional performance in patients with paraplegia. *Arch Phys Med Rehabil* 2013; 84: 1276–1281.
32. Flatters I, Mushtaq F, Hill LJ, Holt RJ, Wilkie RM, Mon-Williams M. The relationship between a child's postural stability and manual dexterity. *Exp Brain Res* 2013; 232: 2907–2917.
33. Connolly AM, Florence JM, Craddock MM, Malkus EC, Schierbecker JR, Siener CA. Motor and cognitive assessment of infants and young boys with Duchenne Muscular Dystrophy: results from the Muscular Dystrophy Association DMD Clinical Research Network. *Neuromuscul Disord* 2013; 23: 529–539.

Figure 1. Repeated measures analysis of variance, reported in means and 0.95% confidence intervals for each subtest of Jebsen-Taylor Test, comparing non-dominant (ND) and dominant (D) upper limbs. The time was registered in seconds (s). There was an interaction between subtest and limb ($P < 0.001$) and *post hoc* Tukey tests showed significant difference between ND and D upper limbs ($P < 0.001$) only in subtest 1.

Table 1. Characteristics of study sample.

Patient	Age (years)	MMSE (score)	Vignos (score)	Brooke (score)	Proximal/ Distal muscle strength	Diagnosis	Dominance	Scoliosis description
1	13	28	1	1	80/97%	DMD	R	Absent
2	16	28	8	3	47/62%	DMD	R	Thoracolumbar R
3	20	28	8	5	27/57%	DMD	R	Thoracolumbar R
4	16	28	8	3	43/53%	DMD	R	Thoracolumbar L
5	28	28	2	1	87/87%	BMD	R	Absent
6	17	26	7	3	50/80%	DMD	L	Thoracolumbar R
7	18	27	8	3	50/63%	DMD	L	Thoracolumbar L
8	25	21	8	3	47/70%	BMD	R	Lumbar L
9	24	16	7	3	47/63%	DMD	R	Thoracolumbar L
10	11	13	1	1	83/82%	DMD	R	Absent
11	20	15	8	5	33/50%	DMD	R	Lumbar L
12	13	30	2	1	70/80%	DMD	R	Thoracolumbar R
13	25	28	6	3	60/62%	BMD	R	Thoracolumbar L
14	13	24	3	2	63/97%	DMD	R	Thoracic R
15	15	30	7	3	50/65%	DMD	R	Lumbar R
16	16	12	8	3	60/60%	DMD	R	Thoracolumbar R
17	23	27	7	4	30/57%	DMD	R	Lumbar L
18	21	29	7	3	50/85%	DMD	R	Lumbar R
19	13	11	7	2	50/65%	DMD	R	Thoracolumbar R
Descriptive data	mean±SD 18.3±5.0	mean±SD 23.6±6.7	median 7	median 3	median 50/66%	16 DMD/ 3BMD	17 R/2 L	10 Thoracolumbar/ 5 lumbar/3 absent/ 1 thoracic
Minimum- maximum	11–28	11–30	1–8	1–5	27–87%/50–97%	–	–	–

DMD/BMD: Duchenne and Becker muscular dystrophies; MMSE: Mini-Mental State Examination; R: right; L: left.

Table 2. Comparison between dominance index of healthy subjects and Duchenne and Becker muscular dystrophies (DMD/BMD) patients, based on Jebsen-Taylor subtests.

Subtest/ Dominance	Healthy subjects		DMD/BMD patients		P
	Mean time	Dominance index	Mean time	Dominance index	
1					
NDUL	20.06	0.414	88.47	0.541	0.193
DUL	8.31		47.89		
2					
NDUL	6.47	0.912	11.33	0.986	0.142
DUL	5.9		11.17		
3					
NDUL	6.85	0.873	27.48	0.832	0.345
DUL	5.98		22.86		
4					
NDUL	7.29	0.809	45.03	0.815	0.479
DUL	5.9		36.69		
5					
NDUL	3.75	0.885	9.99	0.818	0.256
DUL	3.32		8.17		
6					
NDUL	4.14	0.855	19.56	0.739	0.155
DUL	3.54		14.45		

NDUL: non-dominant upper limb; DUL: dominant upper limb; P<0.05: statistical significance (ANOVA).

Table 3. Correlations between times of subtests of Jebsen-Taylor Test (JTT) performed by dominant and non-dominant upper limbs.

	1 ND	1 D	2 ND	2 D	3 ND	3 D	4 ND	4 D	5 ND	5 D	6 ND	6 D
1 ND	–	–	–	–	–	–	–	–	–	–	–	–
1 D	0.948	–	–	–	–	–	–	–	–	–	–	–
2 ND	0.371	–	–	–	–	–	–	–	–	–	–	–
2 D	–	0.228	0.869	–	–	–	–	–	–	–	–	–
3 ND	0.085	–	0.889	–	–	–	–	–	–	–	–	–
3 D	–	0.394	–	0.713	0.713	–	–	–	–	–	–	–
4 ND	0.141	–	0.760	–	0.837	–	–	–	–	–	–	–
4 D	–	0.104	–	0.743	–	0.606	0.773	–	–	–	–	–
5 ND	0.011	–	0.867	–	0.968	–	0.803	–	–	–	–	–
5 D	–	0.112	–	0.949	–	0.661	–	0.808	0.851	–	–	–
6 ND	0.174	–	0.864	–	0.922	–	0.835	–	0.867	–	–	–
6 D	–	0.525	–	0.839	–	0.856	–	0.728	–	0.775	0.830	–

D: dominant upper limb; ND: non-dominant upper limb. Values in bold: $P < 0.05$ (Spearman).

Table 4. Correlations (r) between proximal and distal upper limb muscle strength (MRC), subtests of Jebsen-Taylor Test (JTT), and scores of dimension 3 of Motor Function Measure (MFM D3).

	Vignos score	Age	Proximal muscle strength	Distal muscle strength	MFM D3
Subtest 1 ND	0.099	-0.248	-0.043	-0.117	-0.117
Subtest 1 D	0.176	-0.221	-0.054	-0.147	-0.147
Dominance index 1	0.193	-0.272	-0.033	0.066	0.066
Subtest 2 ND	0.483	0.154	-0.621	-0.621	-0.578
Subtest 2 D	0.368	0.188	-0.555	-0.571	-0.529
Dominance index 2	0.168	0.070	-0.181	0.013	0.013
Subtest 3 ND	0.302	0.197	-0.602	-0.531	-0.461
Subtest 3 D	0.420	0.060	-0.585	-0.715	-0.498
Dominance index 3	0.195	-0.118	0.103	-0.099	-0.099
Subtest 4 ND	0.354	0.074	-0.575	-0.494	-0.483
Subtest 4 D	0.376	0.037	-0.570	-0.579	-0.366
Dominance index 4	0.084	0.168	-0.092	-0.113	-0.097
Subtest 5 ND	0.321	0.225	-0.523	-0.457	-0.330
Subtest 5 D	0.377	0.088	-0.585	-0.626	-0.484
Dominance index 5	0.231	-0.395	-0.536	-0.464	-0.276
Subtest 6 ND	0.442	0.212	-0.767	-0.678	-0.422
Subtest 6 D	0.511	0.087	-0.649	-0.709	-0.709
Dominance index 6	-0.192	-0.110	0.357	0.186	-0.276
Vignos score	–	0.296	-0.847	-0.790	-0.408
Age	0.296	–	-0.255	-0.232	0.289
Proximal muscle strength	-0.847	-0.255	–	0.777	0.304
Distal muscle strength	-0.790	-0.232	0.777	–	0.528
Motor function measure D3	-0.408	0.289	0.304	0.528	–

ND: non-dominant; D: dominant. Values in bold: $P < 0.05$ (Pearson).

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ORIGINAL RESEARCH

Reliability, validity and description of timed performance of the Jebsen-Taylor Test in patients with muscular dystrophies

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Muscular dystrophies;
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Abstract

Background: The Jebsen-Taylor Test evaluates upper limb function by measuring timed performance on everyday activities. The test is used to assess and monitor the progression of patients with Parkinson disease, cerebral palsy, stroke and brain injury.

Objectives: To analyze the reliability, internal consistency and validity of the Jebsen-Taylor Test in people with Muscular Dystrophy and to describe and classify upper limb timed performance of people with Muscular Dystrophy.

Methods: Fifty patients with Muscular Dystrophy were assessed. Non-dominant and dominant upper limb performances on the Jebsen-Taylor Test were filmed. Two raters evaluated timed performance for inter-rater reliability analysis. Test-retest reliability was investigated by using intraclass correlation coefficients. Internal consistency was assessed using the Cronbach alpha. Construct validity was conducted by comparing the Jebsen-Taylor Test with the Performance of Upper Limb.

Results: The internal consistency of Jebsen-Taylor Test was good (Cronbach's $\alpha = 0.98$). A very high inter-rater reliability (0.903–0.999), except for writing with an intraclass correlation coefficient of 0.772–1.000. Strong correlations between the Jebsen-Taylor Test and the Performance of Upper Limb Module were found ($\rho = -0.712$).

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Introduction

New pharmacological and therapeutic interventions during the past three decades contributed to a longer survival of people with Muscular Dystrophy (MD)^{1,2}. Therefore, the number of non-ambulatory people with upper limb dysfunction increased, as the demand for more accurate assessment protocols². The lack of instruments to quantify upper limb functional impairments is a challenge faced by health professionals who work with people with MD³.

Some tests evaluate upper limb motor function in MD or specifically in Duchenne Muscular Dystrophy (DMD), but none evaluate timed performance. Brooke Scale classifies upper limb active movements in DMD and Becker muscular dystrophy (BMD) with a six-point scale⁴. However, Brooke Scale does not quantify functional performance. Dimension three of Motor Function Measure has six items referring to upper limb function⁵. However, in people with less severe MD, the Motor Function Measure may not detect early stage disabilities and may show scoring ceiling effects. ABILHAND questionnaire points the subject's perception of difficulty performing activities of daily living involving upper limb functions⁶. ABILHAND classifies the tasks in fully or partially performed, or not performed at all. Upper limb performance is inferred according to subject's report and not specifically tested. The Performance of Upper Limb (PUL) assesses shoulder, elbow and hand functions in DMD. Four items of this scale measure timed performance only as additional qualitative information, with no impact on the total score⁷.

Timed performance is an accurate functional measure in people with DMD^{8,9} and possibly, with other types of MD. This evaluation strategy has

been used in DMD for assessing lower limbs functional performance as in the six-minute walk test¹⁰, in North Star Ambulatory Assessment¹¹ and in Functional Evaluation Scale for Duchenne Muscular Dystrophy¹². The Jebsen-Taylor Test evaluates upper limbs timed performance in seven subtests that represent everyday activities, such as writing, turning cards, picking up objects or beans with a spoon, stacking checkers and picking up light or heavy cans. The subtests assess the distal and proximal upper limb performance. Materials are standardized and have low-cost. Assessment requires about 35 minutes¹³.

The Jebsen-Taylor Test was translated into Brazilian Portuguese and showed excellent intra and inter-rater reliability in people with stroke, cerebral palsy and Parkinson disease¹⁴⁻¹⁷. Scores are determined by timed performance on functional activities, which differentiates this test from others. The test has normative data for healthy people¹⁸ and was previously applied in boys with DMD and considered as a sensitive method to assess DMD progression. However, psychometric properties were not tested and people with other types of MD were not evaluated¹⁹.

We hypothesized that Jebsen-Taylor Test would generate accurate measures of upper limb motor function in people with Muscular Dystrophy. First, we aimed to analyze the reliability, internal consistency and validity of Jebsen-Taylor Test in people with Muscular Dystrophy. Second, we aimed to describe and classify upper limbs timed performance in people with Muscular Dystrophy.

Method

Experimental design

This is an observational study with cross-sectional design approved by the Federal University of São Paulo Ethics Committee (process 132-193).

Local and participants

All participants submitted to clinical and therapeutic treatment in Brazilian Association of Muscular Dystrophies (ABDIM) were invited (80 people). They had their diagnosis of DMD, BMD, fascioscapulohumeral dystrophy (FSH), limb-girdle muscular dystrophy (LGMD) and Myotonic Dystrophy type 1 (MD1) confirmed by DNA analysis. Consent occurred by signing the consent form by parents/legal guardians. Two participants were excluded due to having associated neurological diseases, three were excluded due to participation refusal by participants/parents/legal guardians, three were excluded due to time unavailability, eight were excluded due to severe cognitive impairment (scoring lower than 11 on Mini-Mental State Examination²⁰⁻²²). In a previous pilot study²¹, we observed that a cut-point of 10 points (instead of eighteen) can be considered for DMD people. Fourteen participants were excluded due to the absence of upper limb function (severe cases, bed restricted). The minimum UL function required to participate in this study was the ability of grasping objects and not just the presence of active muscle contraction in hand and fingers without function. Therefore, participants who were not able to grasp objects were excluded.

The 50 participants included in this study were diagnosed with DMD (72%), LGMD (16%), BMD (6%), MD1 (4%) and FSH (2%). The sample size

was calculated to achieve 80% power with alpha error of 5% and expected intraclass correlation coefficients (ICC) of 0.997¹⁴ using the ICC Sample Size Package. Thus, the sample size required for this study was 49 individuals.

Two raters participated in this study. Both were physical therapists who work with patients with neuromuscular diseases. One of the raters had a master degree and three years of clinical experience with MD and the other had a PhD degree and 15 years of clinical experience with MD. One of the raters had previously worked with Jebsen-Taylor Test.

Procedures

Participants were evaluated by the Mini-Mental State Examination²⁰, to screen for cognitive impairment. Then, hand dominance assessment²³ and Vignos scale²⁴ were performed to classify the participants. The analysis of hand dominance was performed by asking and observing the preferred hand during the manipulation of everyday objects such as scissors, comb, toothbrush and pencil²³. The Vignos scale indicates the clinical staging of people with neuromuscular diseases (from 1 to 10; 1 for subtle changes in posture or gait and 10 for bedridden patients).²⁴ Based on Vignos score, we subdivided the sample in ambulatory (Vignos score 1-6) and non-ambulatory (Vignos score 7-10) to describe timed performance.

Jebsen-Taylor subtests were administered following the sequence: 1: writing; 2: turning over cards; 3: picking up small common objects; 4: simulating feeding; 5: stacking checkers; 6: picking up large light objects. The sequence, instructions, tasks and materials followed the norms previously validated in

Brazilian Portuguese¹³⁻¹⁴. We applied the Jebsen-Taylor Test in people with MD in a previous pilot study.²⁵ Based on the results, we improved the application protocol of the Test and set the inclusion/exclusion criteria of the present study.

Participants were assessed individually. They performed the subtests seated on their wheelchair or on a chair that allowed the correct positioning of hips, knees and ankles, flexed at approximately 90°. A table with adjustable height was used to keep the elbows in approximately 90° flexion, considering the most comfortable position for the subject during the test. Each subtest was performed with the non-dominant upper limb, and then with the dominant upper limb¹³. Time was measured with a stopwatch (not digitally), as commonly used in clinical practice. All trials were filmed from the left and right sides by a digital camera on a tripod located at approximately two meters from the subject. The researcher asked participants to perform the Jebsen-Taylor Test in a comfortable time to simulate the task real condition²⁶.

Raters read the Brazilian Portuguese instructions. After that, they watched films of patients performing the subtests and discussed the scoring of Jebsen-Taylor Test for eight hours.²⁷ Raters were blinded about participants data; they had no access to charts. Raters collected data separately, during the same similar period (in the same week). They watched the videos in different computers and laboratories, but with similar equipment²⁸. Each rater analyzed 12 films correspondent to the non-dominant and dominant attempts of each six subtests of the Jebsen-Taylor Test. Fifteen days after the first assessment, participants were reevaluated by rater 2.

The validation process was conducted by comparing the Jebsen-Taylor Test with the gold standard test used to assess upper limb function in DMD: the

Performance of Upper Limb.²⁹ Participants were evaluated with Performance of Upper Limb in one session. The same positioning adopted to the Jebsen-Taylor Test was used, but only the dominant upper limb was tested.

Statistical analysis

The hypothesis of normal distribution was tested using the Shapiro-Wilk test. Descriptive data analysis was performed to characterize the sample. Tests were run on R Program (Windows version 3.3.2). The level of significance of 5% ($p < 0.05$) was adopted.³⁰

Inter-rater reliability analysis included two evaluations of each film by raters 1 and 2. The analysis was run using ICC and their respective 95% confidence intervals. Very low reliability was considered when ICC was below 0.25, low reliability between 0.26 and 0.49, moderate between 0.50 and 0.69, high between 0.70 and 0.89 and very high reliability when ICC was higher than 0.90. Mann-Whitney tests evaluated the differences between the medians of timed performances measured by two raters and compared the timed performances of ambulatory and non-ambulatory participants.

The internal consistency of the total score of Jebsen-Taylor Test was evaluated by Cronbach's alpha. The classification of the timed performance by Vignos scores of ambulatory and non-ambulatory participants was shown in percentiles. We classified as very good (below 20), good (20-40), moderate (40-60), bad (60-80) and very bad (above 80). The sample was subdivided in DMD and other DM types (FSH, DM1, BMD and LGMD).

To test the validity of Jebsen-Taylor Test, Spearman correlation coefficients verified the relationships between the subtests and the domains of the Performance of Upper Limb.

Results

Sample characteristics are displayed in Table 1.

Table 1

Participants with severe upper limb disability (scored as 7-8 in Vignos scale) showed difficulty during subtests 3 and 4, which required inserting objects or beans into the can. In these cases, subtests 3 and 4 were considered complete when the six small objects or the five beans were placed on the table, near the can.

Psychometric properties analysis

The internal consistency of the total score of the Jebsen-Taylor Test was good (Cronbach's $\alpha = 0.98$). To calculate reliability, each rater analyzed 12 films correspondent to the non-dominant and dominant attempts of each six subtests of the Jebsen-Taylor Test. ICC values, 95% of confidence interval and standard errors of means of inter-rater reliability are displayed in Table 2. Subtests showed very high inter-rater reliability of subtests performed with both non-dominant and dominant limbs, except for the non-dominant upper limb attempt on subtest 1, which showed high inter-rater reliability (Table 2). Therefore, we observed high agreement between the evaluations of raters 1

and rater 2. The correlations between shoulder, elbow and wrist domains of Performance of Upper Limb and Jebsen-Taylor subtests (validation analysis) are demonstrated in Table 3.

Tables 2 and 3

Timed performance analysis

Timed performance of ambulatory and non-ambulatory participants with DMD (n=36) and other DM types (FSH, DM1, BMD and LGMD; n=14) is described on Table 3.

The median time to the non-dominant and dominant performances on each subtest is presented. We found a significant difference between ambulatory (n=11) and non-ambulatory (n=25) DMD participants: non-ambulatory participants showed longer times on non-dominant and dominant upper limbs performances on subtests 2, 3, 4 and 6.

We found a significant difference between ambulatory (n=7) and non-ambulatory (n=7) participants with other DM types: non-ambulatory participants showed longer times on non-dominant and dominant upper limbs performances on subtests 2, 3, and 6. They also differed in dominant upper limb performance of subtest 5: a higher median was observed in non-ambulatory participants (Table 4).

Ambulatory (n=36) and non-ambulatory (n=11) participants with DMD had their timed performance classified as *very good*, *good*, *moderate*, *bad* or *very bad*. Non-dominant and dominant upper limbs performances on each subtest are displayed in Table 5.

Tables 4 and 5

Discussion

The present study described upper limbs timed performance and analyzed the reliability, internal consistency and validity of Jebsen-Taylor Test in people with Muscular Dystrophy.

Jebsen-Taylor Test showed very high ICC values, which reflects a high agreement between raters. For the calculation of ICC, the value of the variation between participants was divided by the total variation, which included the variation between participants and the not intended variation (“error”). The variation due to errors included different components depending on the design of the study. As the study design involved the evaluation of time by means of filming, we believe that the error was lower. High values of coefficient of variation between the subtests were observed. The high values are due to the variation on the performance of each participant and are not related to the variation of the instrument or the rater. Even though the participants had high variability in the tests, the raters presented a great agreement and the test showed a good internal consistency.

Only the writing subtest did not demonstrate very high, but high inter-rater reliability, which not interferes on the quality of the findings. Subtest 1 (writing) was previously considered unsuitable for people with DMD, because it may be influenced by cognitive and/or learning difficulties, often associated with MD, mainly DMD¹⁹. The present study showed that this activity can be used with people with DMD (and other types of MD), as long as they can read and write. The assessment of writing, which has motor and cognitive demands, is important for better understanding UL function.

The times on Jebsen-Taylor Test were correlated to Performance of Upper Limb scores. Considering that the Performance of Upper Limb is the gold standard assessment for upper limb function, we can consider that the Jebsen-Taylor Test is valid for measuring timed performance. A previous pilot study also found strong correlation between Jebsen-Taylor Test and Performance of Upper Limb.³¹

The good psychometric properties found indicate that timed performance can be used to measure the progression of muscle weakness¹⁴ and upper limb motor function in participants with MD. The Jebsen-Taylor Test was previously applied in people with DMD by Hiller and Wade¹⁹, who identified that short times were indicators of upper limbs muscles preservation.

Participants could perform all subtests of Jebsen-Taylor Test and did not refer any pain or discomfort during the procedures. Subtests 3 and 4 required adaptations for people with severe UL disability (scored as 7-8 in Vignos Scale). They were asked to place the six small objects or the five beans on the table, near the can, instead of inserting objects or beans into the can. It is important to mention that these did not interfere on the test internal consistency, reliability or validity.

Normative values for healthy subjects were previously studied.¹⁸ All DMD participants and non-ambulatory DM participants showed increased time to perform subtests of the Jebsen-Taylor Test in comparison with the normative data. However, ambulatory DM participants exhibited similar time to perform the non-dominant and the dominant attempt of the subtests 2, 3, 5 and 6 compared to the healthy controls.

We found some differences on timed performance of ambulatory and non-ambulatory people with DMD and with MD types. DMD non-ambulatory participants showed significant higher times in turning over cards, picking up small common objects, simulating feeding and picking up large light objects. In the other DM types group, non-ambulatory participants showed significant higher times in turning over cards, picking up small common objects, stacking checkers and picking up large light objects. These tasks were more sensitive to detect differences in upper limb performance considering MD progression. These findings can be used in clinical practice with ambulatory and non-ambulatory patients. Very few biomarkers involving upper limb functions are currently available for decision making in clinical practice. The description of timed performance and the establishment of performance categories can help therapists develop clinical strategies. Quantitative information involving motor function is useful for monitoring MD progression in research and clinical practice.

Subtests instructions did not determine specific upper limbs movements or positions, just the task aims. Compensatory movements were observed, because muscle weakness impairs upper limbs performance and restricts movements, which elicits the selection of new motor strategies.³²⁻³³ Compensatory movements increase as motor function decreases, with MD progression.³³⁻³⁴ However, a high number of compensatory movements can result in variability in performance, not only in people with DMD, but also with other types of MD. Our sample showed high standard-deviations in all subtests, which exemplifies such variability. Besides, subtests involve gripping and holding and require proximal stability. Functional motor loss usually occurs from

proximal to distal and the lack of proximal stability may impair upper limbs timed performance⁹. Future studies should evaluate if some proximal upper limb assistance would help the performance on Jebsen-Taylor Test in people with MD.

It is important to mention that the present study has some limitations. It was not possible to compare timed performance between people with MD and healthy participants due to the absence of a control group. However, the normative data of Jebsen-Taylor Test is available in literature¹⁸ for such comparison and analysis. Another important point is that Jebsen-Taylor Test should not be used to evaluate people with severe UL impairment (e.g. Vignos score 9) because of ceiling effects. Additionally, people with severe UL disability may need adaptations for picking up small common objects and simulating feeding testing. Finally, we must mention the lack of compensatory movement assessment. The description of compensatory movements can contribute for better understanding functional independence. Many people with MD employ compensatory movements to keep performing tasks that become difficult as muscle weakness progresses.^{10,33}

To sum up, Jebsen-Taylor Test is a reliable and valid method to evaluate upper limbs performance in people with MD. The description and classification of timed performance provides normative data for clinical practice and research. Timed performance is a reliable measure for upper limb function in this population.

References

1. Shin J, Tajrishi MM, Ogura Y, Kumar A. Wasting mechanisms in muscular dystrophy. *J Immunol*. 2013;45:2266-79.
2. Kohler M, Clarenbach CF, Bahler C, Brack T, Russi EW, Bloch KE. Disability and survival in Duchenne muscular dystrophy. *J Neurol Neurosurg Psychiatry*. 2009;80:320-5.
3. Mercuri E, Mayhew A, Muntoni F, Messina S, Straub V, Van Ommen GL, et al. Towards harmonization of outcome measures for DMD and SMA within TREAT-NMD; report of 3 expert workshops: TREAT-NMD/ ENMC workshop on outcome measures, 12th-13th May 2007, Naarden, The Netherlands; TREAT-NMD workshop on outcome measures in experimental trials for DMD, 30th June-1st July 2007, Naarden, The Netherlands; conjoint Institute of Myology TREAT-NMD meeting on physical activity monitoring in neuromuscular disorders, 11th July 2007, Paris, France. *Neuromuscular Disord*. 2008;18:894-903.
4. Brooke MH, Griggs RC, Mendell JR, Fenichel GM, Shumate JB, Pellegrino RJ. Clinical trial in Duchenne dystrophy: I design of protocol. *Muscle Nerve*. 1981;4:186-97.
5. Bérard C, Payan C, Fermanian J, Girardot F, Groupe d'Etude MFM. A motor function measurement scale for neuromuscular disease - description and validation study *Rev Neurol*. 2006;162:485-93.
6. Vandervelde L, Van den Bergh PY, Penta M, Thonnard JL. Validation of the ABILHAND questionnaire to measure manual ability in children and adults with neuromuscular disorders. *J Neurol Neurosurg Psychiatry*. 2010;81:506-12.

7. Mayhew A, Mazzone ES, Eagle M, Duong T, Ash M, Decostre V, et al. Development of the performance of the upper limb module for Duchenne muscular dystrophy. *Dev Med Child Neurol*. 2013;55:1038-45.
8. Beenakker EA, Maurits NM, Fock JM, Brouwer OF, Van der Hoeven JH. Functional ability and muscle force in healthy children and ambulant Duchenne muscular dystrophy subjects. *Eur J Paediatr Neurol*. 2005;9:387-93.
9. Martini J, Hukuda ME, Caromano FA, Favero FM, Fu C, Voos MC. The clinical relevance of timed motor performance in children with Duchenne muscular dystrophy. *Physiother Theory Pract*. 2014;24:1-9.
10. Pane M, Mazzone ES, Sivo S, Fanelli L, De Sanctis R, D'Amico A, et al. The 6 minute walk test and performance of upper limb in ambulant duchenne muscular dystrophy boys. *Plos Curr*. 2014;6:pil:ecurrents.md.a93d9904d57dcb08936f2ea89bca6fe6.
11. De Sanctis R, Pane M, Sivo S, Ricotti V, Baranello G, Frosini S, et al. Suitability of North Star Ambulatory Assessment in young boys with Duchenne muscular dystrophy. *Neuromuscul Disord*. 2015;25(1):14-8.
12. Albuquerque PS, Voos MC, Simões MS, Martini J, Monteiro CB, Caromano FA. Responsiveness of the domain climbing up and going down stairs of the Functional Evaluation scale for Duchenne Muscular Dystrophy: a one-year follow-up. *Braz J Phys Ther*. 2016;20(5):471-6.
13. Jebson RH, Taylor N, Triechmann RB, Trotter MJ, Howard LA. An objective and standardized test of hand function. *Arch Phys Med Rehabil*. 1969;50:311-9.

14. Ferreiro KN, Santos RL, Conforto AB. Psychometric properties of the Portuguese version of the Jebsen-Taylor test for adults with mild hemiparesis. *Braz J Phys Ther.* 2010;14(5):377-81.
15. Sears ED, Chung KC. Validity and responsiveness of the Jebsen-Taylor hand function test. *J Hand Surg.* 2010;35:30-7.
16. Charles JR, Wolf SL, Schneider JA, Gordon AM. Efficacy of child-friendly form of constraint induced movement therapy in hemiplegic cerebral palsy: a randomized controlled trial. *Dev Med Child Neurol.* 2006; 48(8):635-42.
17. Mak MKY, Lau ETL, Tam VWK, Woo CWY, Yuen SKY. Use of Jebsen Taylor hand function test in evaluating the hand dexterity in people with Parkinson's disease. *J Hand Ther.* 2015;28:389-95.
18. Sarafraz Z, Vahedi Z, Feyzi A, Behnia F. Hand function related to age and sex. *Iran Rehab J.* 2008;6(7):10-5.
19. Hiller LB, Wade CK. Upper extremity functional assessment scales in children with Duchenne muscular dystrophy: a comparison. *Arch Phys Med Rehabil.* 1992;73:527-34.
20. Folstein MF, Folstein SE, McHugh PR. Mini-Mental State: a practical method for grading the cognitive state of subjects for clinician. *J Psychiatr Res.* 1975;12:189-98.
21. Voos M, Favero F, Dias K, Artiheiro M, Oliveira A, Caromano F. Dissociation between motor and cognitive skills in subjects with Duchenne muscular dystrophy. *Neuromuscul Disord.* 2015; 25(Suppl 2):S306.
22. Rubial-Alvarez S, Machado MC, Sintas E, Sola S, Böhm P, Peña-Casanova J. A preliminary study of the mini-mental state examination in a Spanish child population. *J Child Neurol.* 2007; 22(11):1269-73.

23. Oldfield RC. The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychol.* 1971; 9(1):97-113.
24. Vignos PJ, Spencer GE, Archibald KC. Management progressive muscular dystrophy of childhood. *JAMA.* 1963;184:89-96.
25. Artilheiro MC, Sá CSC, Fávero FM, Caromano FA, Voos MC. Patients with Duchenne and Becker Muscular Dystrophy are not more asymmetrical than healthy controls on timed performance of upper limb tasks. *Braz J Med Biol Res.* 2017;50:e6031.
26. Fernandes LAY, Caromano FA, Assis SMB, Hukuda ME, Voos MC, Carvalho EV. Relationship between the climbing up and climbing down stairs domain scores on the FES-DMD, the score on the Vignos Scale, age and timed performance of functional activities in boys with Duchenne muscular dystrophy. *Braz J Phys Ther.* 2014;18(6):513-20.
27. Garcia Júnior A, Caromano FA, Contesini AM, Escorcio R, Fernandes LAY, João SMA. Thoracic cirtometry in children with Duchenne muscular dystrophy: expansion of the method. *Braz J Phys Ther.* 2013;17(1):1-18.
28. Iunes DH, Castro FA, Salgado HS, Moura IC, Oliveira AS, Bevilaqua-Grossi D. Intra and inter-examiner reliability and method repeatability of postural evaluation via photogrammetry. *Braz J Phys Ther.* 2005;9(3):327-34.
29. Mayhew A, Mazzone ES, Eagle M, Duong T, Ash M, Decostre V et al. Development of the performance of the upper limb module for Duchenne muscular dystrophy. *Dev Med Child Neurol.* 2013;55:1038-45.

30. Rathbone A, Shaw S, Kumbhare D (2015). ICC sample size: Calculation of sample size and power for ICC. R package version 1.0. <http://CRAN.R-project.org/package=ICC.Sample.Size>
31. Artilheiro MC, Cardoso de Sá CD, Fávero FM, Wutzki HC, de Resende MB, Caromano FA, Voos MC. Hand Function in Muscular Dystrophies. *Percept Mot Skills*. 2017;124(2):441-51.
32. Mazzone E, Vasco G, Palermo C, Bianco F, Galluccio C, Ricotti V, et al. A critical review of functional assessment tools for upper limbs in Duchenne muscular dystrophy. *Dev Med Child Neurol*. 2012;54(10):879-85.
33. Martini J, Voos MC, Hukuda ME, Resende MBD, Caromano FA. Compensatory movements during functional activities in ambulatory children with Duchenne muscular dystrophy. *Arq Neuropsiquiatr*. 2014;72:5-11.
34. Bartels B, Pangalila RF, Bergen MP, Cobben NAM, Stam HJ, Roebroek ME. Upper limb function in adults with Duchenne muscular dystrophy. *J Rehabil Med*. 2011;43:12-7.

Table 1: Sample characteristics: Muscular Dystrophy type, sex, upper limb dominance, age, Vignos scale score and Mini Mental State Examination score.

MD type	N (%)	Sex	Dominance	Age	Vignos	MMSE
FSH	1 (2%)	1 F	1 R	19	7	29
DM1	2 (4%)	1 M/ 1 F	2 R	22.5 (16.26)	1	22 (5.65)
BMD	3 (6%)	3 M	3 R	25 (1.73)	6 (3.05)	28 (4.04)
LGMD	8 (16%)	7 M/ 1 F	7 R/ 1 L	24.5 (9.16)	7 (2.42)	28.5 (0.74)
DMD	36 (72%)	36 M	31 R/ 5 L	13 (4.18)	7 (2.25)	27 (6.73)

FSH: facioscapulohumeral muscular dystrophy; DM1: Myotonic dystrophy type 1; BMD: Becker muscular dystrophy; LGMD: limb-girdle muscular dystrophy; DMD: Duchenne Muscular Dystrophy; N: number; M: male, F: female; R: right; L: left; Vignos: Vignos scale score; MMSE: Mini-Mental State Examination score.

Table 2: Means and 95% confidence intervals (95% CI), means standard errors (SE) and intraclass correlation coefficients (ICC) of inter-rater reliability analysis.

	Rater 1 (N=50)	Rater 2 (N=50)	P-value	ICC	95% CI	SE	CV Rater 1	CV Rater2
1 ND	92.13 ± 8.8	86.87 ± 7.88	0.657	0.772	[0.632, 0.864]	8.24	0.68	0.64
1 D	63.53 ± 9.85	63.48 ± 9.86	0.997	1.000	[1.000, 1.000]	0.00	1.10	1.10
2 ND	13.24 ± 9.11	13.23 ± 1.1	0.996	0.998	[0.997, 0.999]	0.80	0.59	0.59
2 D	11.87 ± 1.06	12.04 ± 1.07	0.911	0.997	[0.994, 0.998]	0.11	0.63	0.63
3 ND	23.71 ± 3.96	24.35 ± 4.4	0.914	0.983	[0.971, 0.991]	1.01	1.18	1.28
3 D	18.91 ± 2.71	17.92 ± 2.31	0.782	0.903	[0.836, 0.944]	1.65	1.01	0.91
4 ND	41.30 ± 8.3	42.35 ± 8.45	0.929	0.999	[0.998, 0.999]	0.51	1.42	1.41
4 D	30.77 ± 5.98	31.15 ± 6.08	0.964	0.999	[0.998, 0.999]	0.37	1.37	1.38
5 D	12.58 ± 1.63	12.88 ± 1.63	0.897	0.997	[0.995, 0.998]	0.17	0.91	0.90
5 ND	9.24 ± 1.1	9.37 ± 1.09	0.934	0.992	[0.986, 0.995]	0.17	0.84	0.83
6 D	18.77 ± 2.71	19.02 ± 2.74	0.923	0.999	[0.999, 1.000]	0.17	1.02	1.02
6 ND	13.75 ± 1.85	14.03 ± 1.93	0.923	0.995	[0.992, 0.997]	0.26	0.95	0.98

P-value ≤ 0.05, ICC: intraclass correlation coefficient, 95% CI: 95% confidence interval, SE: mean standard error, CV: coefficient of variation.

Table 3: Spearman correlation coefficients between Performance of Upper Limb domains (shoulder, elbow and wrist) and Jebsen-Taylor subtests (1-6).

	PUL Shoulder	PUL Elbow	PUL Wrist	PUL Total	JTT 1	JTT 2	JTT 3	JTT 4	JTT 5	JTT 6	JTT Total
PUL Shoulder	1.000										
PUL Elbow	0.821	1.000									
PUL Wrist	0.802	0.813	1.000								
PUL Total	0.868	0.895	0.956	1.000							
JTT 1 Writing	-0.143	-0.156	-0.190	-0.129	1.000						
JTT 2 Turning over cards	-0.644	-0.677	-0.717	-0.751	0.269	1.000					
JTT 3 Picking up small objects	-0.685	-0.686	-0.821	-0.816	0.381	0.886	1.000				
JTT 4 Simulating feeding	-0.666	-0.725	-0.755	-0.780	0.432	0.745	0.877	1.000			
JTT 5 Stacking checkers	-0.700	-0.670	-0.760	-0.791	0.371	0.826	0.913	0.863	1.000		
JTT 6 Picking up large objects	-0.736	-0.746	-0.867	-0.854	0.399	0.887	0.927	0.841	0.871	1.000	
JTT Total	-0.587	-0.642	-0.722	-0.712	0.672	0.793	0.876	0.899	0.857	0.891	1.000

PUL: Performance of Upper Limb, JTT: Jebsen-Taylor Test.

Table 4: Descriptive statistics of Jebsen-Taylor Test for ambulatory and non-ambulatory participants with Duchenne Muscular Dystrophy (DMD) and with other Muscular Dystrophy types (MD).

	Ambulatory DMD (N=11)					Non-ambulatory DMD (N=25)					P-value
	Median	P25	P75	Min	Max	Median	P25	P75	Min	Max	
1 ND	86.45	74.65	100.25	28.13	145.80	74.23	65.00	101.10	47.81	296.60	0.692
1 D	52.23	34.32	66.86	21.56	193.50	40.20	31.43	69.30	15.60	295.40	0.877
2 ND	9.46	5.32	12.33	3.28	35.20	14.28	12.68	19.30	5.85	30.20	0.004
2 D	9.09	5.94	11.79	3.19	14.40	14.09	9.46	15.60	5.41	43.30	0.007
3 ND	8.53	6.79	12.52	5.63	30.20	22.16	13.28	28.50	7.53	122.60	0.001
3 D	9.38	6.38	11.73	5.06	15.70	14.22	12.26	32.80	8.45	94.30	0.001
4 ND	10.19	6.52	14.39	5.06	19.60	26.78	16.34	73.50	9.46	234.60	0.000
4 D	9.54	8.12	11.27	6.29	16.10	18.54	12.09	35.50	7.46	133.60	0.000
5 ND	10.00	6.81	13.3	2.25	23.30	11.05	9.23	14.00	2.69	40.20	0.372
5 D	7.84	5.42	9.92	1.87	12.60	9.46	8.75	12.20	3.75	34.40	0.131
6 ND	7.38	5.22	8.82	4.22	13.30	18.00	11.37	35.90	5.59	69.90	0.000
6 D	7.28	6.22	8.41	3.28	12.40	12.47	9.35	22.60	5.39	37.30	0.002

	Ambulatory MD (N=7)					Non-ambulatory MD (N=7)					P-value
	Median	P25	P75	Min	Max	Median	P25	P75	Min	Max	
1 ND	48.47	36.78	53.34	24.09	131.69	58.09	46.66	65.9	36.97	140.9	0.225
1 D	21.45	19.46	22.21	13.60	89.99	22.75	19.35	32.3	12.72	49.6	0.565
2 ND	6.21	5.12	7.01	3.41	9.03	8.15	7.41	23.6	5.94	31.4	0.035
2 D	5.67	4.62	6.00	4.31	6.31	8.78	6.80	17.2	5.38	23.3	0.008
3 ND	7.16	6.64	8.87	6.44	14.78	14.47	10.61	61.7	7.90	126.7	0.035
3 D	6.61	6.15	8.23	5.62	11.68	13.63	9.59	39.4	7.40	78.6	0.009
4 ND	10.72	10.07	17.72	9.31	28.81	18.75	13.35	89.4	10.37	281.5	0.110
4 D	9.59	7.87	14.64	7.25	24.22	18.44	13.41	81.7	8.47	214.0	0.110
5 ND	3.16	2.94	3.78	1.92	5.85	6.10	3.90	36.6	2.44	57.7	0.142
5 D	2.40	1.99	2.78	1.29	4.59	5.94	4.62	10.8	2.03	45.9	0.018
6 ND	5.28	4.86	5.45	4.53	10.03	11.06	8.12	53.2	5.12	86.8	0.013
6 D	4.56	4.35	5.62	4.14	12.69	12.14	7.72	25.6	5.38	83.3	0.013

25p = 25th percentile, 75p = 75th percentile, min = minimum, max = maximum, ND = non-dominant upper limb, D = dominant upper limb, P-value $\leq$ 0.05.

Table 5: Classification of the non-dominant and dominant upper limbs timed performance on Jebsen-Taylor Test of ambulatory and non-ambulatory participants with Duchenne Muscular Dystrophy.

		Non-dominant		Dominant	
		Ambulatory (N=11)	Non-ambulatory (N=25)	Ambulatory (N=11)	Non-ambulatory (N=25)
1	Very Good	< 73	< 58	29	< 28
	Good	73 to 76	58 to 71	29 to 44	28 to 34
	Moderate	76 to 92	71 to 90	44 to 52	34 to 65
	Bad	92 to 106	90 to 170	52 to 70	65 to 143
	Very bad	> 106	> 170	> 70	> 143
2	Very Good	< 4	< 12.3	< 5	< 9
	Good	4 to 7	12 to 13	5 to 7	9 to 13
	Moderate	7.31 to 9.6	13 to 15	7 to 10	13 to 14
	Bad	9.6 to 12	15 to 20	10 to 12	14 to 16
	Very bad	> 12	> 20	> 12	> 16
3	Very Good	< 6	< 12	< 6	< 12
	Good	6 to 8	12 to 18	6 to 8	12 to 13
	Moderate	8 to 10	18 to 24	8 to 10	13 to 16
	Bad	10 to 13	24 to 35	10 to 13	16 to 35
	Very bad	> 13	> 35	> 13	> 35
4	Very Good	< 6	< 14	< 7	< 12
	Good	6 to 9	14 to 20	7 to 9	12 to 16
	Moderate	9 to 14	20 to 39	9 to 10	16 to 24
	Bad	14 to 15	39 to 80	10 to 11	24 to 43
	Very bad	> 15	> 80	> 11	> 43
5	Very Good	< 4	< 7	< 5	< 7
	Good	4 to 9	7 to 11	5 to 7	7 to 9
	Moderate	9 to 12	11 to 13	7 to 9	9 to 10
	Bad	12 to 14	13 to 15	9 to 10	10 to 13
	Very bad	> 14	> 15	> 10	> 13
6	Very Good	< 5	< 11	< 6	< 9
	Good	5 to 7	11 to 16	6 to 7	9 to 11
	Moderate	7 to 8	16 to 20	7 to 8	11 to 14
	Bad	8 to 9	20 to 37	8 to 9	14 to 25
	Very bad	> 9	> 37	> 9	> 25

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Bringing the spoon to the mouth or the head to the spoon? The analysis of compensatory strategies to perform the upper limb task in Duchenne muscular dystrophy: a case-control study

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Abstract

Introduction: The difficulty bringing the spoon to the mouth is frequently reported by patients with Duchenne muscular dystrophy. This functional task can reveal compensatory movements that are employed to maintain performance facing muscle weakness. This study aimed to describe and compare the performance of patients with Duchenne muscular dystrophy and controls in bringing the spoon to the mouth and to describe the compensatory movements performed during the task. **Methods:** Twenty-six patients and twenty-two healthy controls were filmed while performing bringing the spoon to the mouth (simulated feeding). Six kinematic variables were used to evaluate the compensatory movements: initial and final angle of head flexion; initial and final angle of elbow flexion; peak velocity and total time. Kinovea (version 8.25) and Statistica (version 13.0) softwares were used for data analyses. **Results:** patients with Duchenne muscular dystrophy showed increased initial and final angles of elbow flexion, increased final angle of head flexion and increased timed performance. **Conclusion:** Patients with Duchenne muscular dystrophy showed significantly more compensatory movements than controls. Simulated feeding assessment can be used in clinical practice to describe compensatory movements secondary to muscle weakness in initial and/or late stages of Duchenne muscular dystrophy.

Keywords: muscular dystrophy; upper extremity; disability evaluation; physical therapy modalities; kinematics.

Introduction

Understanding the performance of daily life activities is essential for assessing upper limb impairment and deciding about therapeutic approaches¹. Upper limb function plays a central role in daily life activities and functional independence in people with Duchenne muscular dystrophy (DMD)².

The difficulty bringing the spoon to the mouth is frequently reported by patients with DMD³. Feeding dependence may cause helplessness, embarrassment and social activities avoidance. The detailed assessment of bringing a spoon to the mouth may help preventing pain, contractures and deformity in trunk and upper limbs. It may also help clinical reasoning and treatment planning with therapeutic exercises and orthoses.

The Performance of Upper Limb test evaluates bringing the hand to the mouth, nevertheless, it does not describe the ability of holding a spoon⁴. The Jebsen Taylor test (JTT) evaluates the ability of holding a spoon and picking and transferring beans. However, it does not assess bringing the spoon to the mouth⁵.

Bringing the spoon to the mouth is a complex functional task. It involves most of upper limb joints and can reveal specific motor performance impairments caused by contractures and weakness⁶. It can be reproducible and may evidence compensatory movements that impact on time and accuracy⁷ in patients with DMD⁸⁻¹⁰.

The description of timed performance and compensatory movements of DMD patients in bringing the spoon to the mouth may generate useful

normative data for clinical and research purposes. The aims of this study were to compare the performance of patients with DMD and controls in bringing the spoon to the mouth and to describe the compensatory movements employed during the task. We hypothesized that patients with DMD with mild motor impairment would be able to bring the spoon to the mouth, whereas patients with severe motor impairment would adopt the strategy of bringing the head to the spoon, by increasing head flexion, due to the inability of lifting the elbow from the table support.

Method

Experimental design

This is a cross-sectional observational case-control study approved by Clinics Hospital – Faculty of Medicine of University of São Paulo Ethics Committee (process 1.755.008).

Volunteers

The Brazilian Association of Muscular Dystrophies had a list of 97 patients with muscular dystrophies, who were followed by the rehabilitation team. Forty patients were not eligible due to having other types of dystrophy (not DMD). Fifty-seven were invited to participate and 34 volunteered. Four were excluded due to the absence of UL function (bed restricted patients), three were excluded due to severe cognitive impairment (less than ten points on Mini-Mental State Examination)¹², one was excluded due to having an associated neurological disease.

Patients (N=26, 13.8 ± 3.6 years) had their DMD diagnosis confirmed by DNA analysis (Table 1). Consent occurred by signing the form by parents/ legal guardians.

Healthy male individuals (N=22, 21 ± 5.8 years) were included as controls (Table 1). These volunteers were university students and their relatives or friends, who were invited in person or by e-mail. Exclusion criteria were prior surgical procedures on upper limbs, rheumatic, orthopedic, psychiatric or neurological diseases and self-reported visual or hearing impairments.

Table 1

Assessment procedures

DMD patients were classified by Vignos score to characterize the motor profile¹¹. The Mini-mental state examination¹² was applied and patients who scored less than 10 were excluded.

Patients and controls had the upper limb dominance assessed by asking and observing the preferred hand during the manipulation of everyday objects such as scissors, comb, toothbrush and pencil.¹³ Only the dominant upper limb performed the task.

Volunteers were assessed individually. They performed the subtests seated on their wheelchair (DMD patients) or on a chair with arm support (DMD patients or controls), which allowed the correct positioning of hips, knees and ankles flexed at approximately 90°. A table with adjustable height was used to keep the elbows in approximately 90° flexion, considering the most comfortable position for each participant. During the test, the volunteers remained with the

arms and trunk undressed to ensure the correct observation of the anatomic structures.

Participants were asked to pick five beans with a spoon, one at a time, and then bring the bean close to the mouth to simulate feeding. They were instructed to let the bean fall when the spoon was close to the mouth (Figure 1). Two attempts were performed. The first was excluded (task familiarization) and the second was analyzed.

Figure 1

The volunteers did not receive specific instructions about movements or UL positioning. Trials were filmed and analyzed in the sagittal plane, in the right or left side, according to limb dominance. A Sony Cybershot® digital camera was attached to a tripod and positioned two meters from the table approximately. The height of the chair\ wheelchair was used as standardization of the camera height.

Compensatory movements analysis

The one-dimensional kinematic analysis was run in Kinovea (version 8.25).¹⁴ Six kinematic variables were used to evaluate the compensatory movements, divided into angular parameters (initial and final angle of head flexion, initial and final angle of elbow flexion) and time parameters (timed performance and the peak velocity reached during the spoon transport).

To determine initial and final angles, anatomic structures were selected. A vertical line aligned with the trunk, ear lobe and acromium were adopted as a reference for head movements. Acromion, humerus lateral

epicondyle, and ulna styloid process were marked as a reference for elbow movements. The marker positioned at the ulna styloid process was the reference to determine the trajectory from the table to the mouth. Timed performance and the peak velocity reached during the spoon transport were analyzed.

Data analysis

The Kolmogorov–Smirnov test showed normal distribution and Levene Test confirmed homogeneity. Analyses of variance (ANOVA) were run to compare the mean differences and to investigate possible interactions between the kinematic variables. To calculate the effect size (ES), the partial eta square was calculated¹⁵. In order to classify the ES, we used a qualitative scale developed by Cohen and adapted by Rosenthal¹⁶. Tukey post hoc Tests were run for multiple comparisons when ANOVA showed significant main effect. The level of significance was set at 5% ($p < 0.05$). Statistica 13.0 (Statsoft, USA) was used in all analyses.

Results

Figure 2 shows elbow and head angles variability during bringing the spoon to the mouth in patients with DMD and controls. We found an interaction between groups and angles (in initial and final positions), with $F(1,46) = 13.618$, $P = 0.0006$. A significant difference was found between initial and final elbow angles in patients with DMD ($P < 0.001$) and controls ($P < 0.001$). No difference was found between groups at the initial ($P = 0.090$) elbow flexion

angle, whereas significant differences were found in final ($P=0.040$) elbow flexion. Patients with DMD showed less elbow flexion than controls in the final position.

The initial and final angles of head flexion were significantly different in patients with DMD ($P<0.001$). However, no differences were found in the controls ($P=0.520$). Intergroup comparison showed no significant differences between initial angles ($P=0.820$), whereas head flexion final angles were greater in patients with DMD ($P<0.025$).

Figure 2

Time parameters showed significant difference between groups. The timed performance was longer in patients with DMD ($F(1,46)$, $ES=18.804$, $P=0.0001$). Peak velocity reached during the spoon transport was lower in patients with DMD, but not statistically different between the groups ($F(1,46)$, $ES=1.639$, $P=0.21$) (Figure 3).

Figure 3

Discussion

Simulated feeding showed specific upper limb impairments in both ambulatory and non-ambulatory patients with DMD. We observed distinct kinematic characteristics between patients with DMD and controls and the presence of compensatory strategies even in early stages of DMD. A previous study¹⁷ reported that compensatory movements emerge in young non-ambulatory patients, until the severe weakness replaces the potential for adaptation. People with DMD employ a larger percentage of their maximal

possible muscle activation in the primary muscles and also in compensatory muscles.¹⁸ Nevertheless, the progression of muscle weakness induces the selection of new motor strategies.⁹

We believe the performance of the simulated feeding task was similar to the real condition of daily feeding and also that patients with DMD were functional due to the compensatory movements. The high number of motor strategies employed by the patients resulted in variability of performance.

The task depends mainly on the elbow flexion, which can be observed in the sagittal plane. As the elbow flexion angle was smaller in patients with DMD, shoulder and wrist movements were performed to facilitate reaching the mouth with the spoon.⁶

The elbow flexors weakness of patients with DMD did not prevent the differences between initial and final elbow angles. Although patients with Duchenne muscular dystrophy ended the movement with less elbow flexion, compared to controls, the angular variation was not different between the groups. Spoon transporting requires concentric contraction of elbow flexors. Therefore, compensatory shoulder and wrist movements allow the completion of the task with less elbow flexion and a functional and efficient spoon trajectory.¹⁹

Compensatory head movements of patients with DMD in upper limb tasks have not been previously quantified. Patients showed distinct initial and final angles of head flexion. This was not observed in controls, which demonstrate similar initial and final angles, i.e., no significant head movement to perform the task. Patients with DMD used increased head flexion as a strategy to achieve the spoon with the mouth and to compensate the elbow flexors

weakness or lack of resistance, since bringing the spoon to the mouth is repeated several times during a meal. Interestingly, the initial position of the head was not different between groups, which shows that head flexion increases during the elbow flexion in patients with DMD. Therefore, we confirmed our initial hypothesis that many patients performed head movements to reach the spoon.

The increased timed performance in patients with DMD was recently described.²⁰ Upper limbs timed performance was firstly assessed in patients with DMD by Hiller and Wade³, who identified that shorter times denoted upper limb muscles preservation. We considered increased timed performance as an important compensatory strategy to overcome muscle weakness. The task involved holding the spoon and required proximal and distal stability simultaneously. Functional motor loss usually occurs in the proximal to distal direction and the lack of proximal stability may have increased timed performance.⁴ The peak velocity in patients with DMD, however, was not different from controls. The increased timed performance did not significantly influence the peak velocity.

Patients with DMD employ trunk compensatory movements.²¹ Future studies should evaluate trunk compensatory movements that help upper limb performance, as well as the compensatory movements observed in the frontal plane.

Physical and occupational therapists clinical practice should identify a combination of compensatory movements, as decreased elbow flexion and increased head flexion, described in the present study, for more accurate therapeutic approaches and decision making about wheelchairs, orthoses and

daily living adaptations. Moreover, compensatory movements should be assessed frequently to follow the functional progression of patients with DMD.⁹ We encourage the use of Kinovea or similar kinematic tools in the clinical routines.

Simulated feeding is a relevant clinical tool to measure upper limb performance and to identify compensatory movements caused by muscle weakness in initial and/or late stages of DMD.

References

1. Janssen, MMHP, Bergsma A, Geurts ACH, de Groot JM. Patterns of decline in upper limb function of boys and men with DMD: an international survey. *J Neurol*. 2014; 261:1269-88.
2. Connolly AM, Malkus EC, Mendell JR, Flanigan KM, Miller JP, Schierbecker JR et al. Outcome reliability in non-ambulatory boys/men with duchenne muscular dystrophy. *Muscle Nerve*. 2015; 51:522-32.
3. Hiller LB, Wade CK. Upper extremity functional assessment scales in children with Duchenne muscular dystrophy: a comparison. *Arch Phys Med Rehabil*. 1992; 73:527-34.
4. Mayhew A, Mazzone ES, Eagle M, Duong T, Ash M, Decostre V et al. Development of the performance of the upper limb module for Duchenne muscular dystrophy. *Dev Med Child Neurol*. 2013; 55:1038-45.
5. Jebsen RH, Taylor N, Triechmann RB, Trotter MJ, Howard LA. An objective and standardized test of hand function. *Arch Phys Med Rehabil*. 1969;50: 311-19.

6. Vandervelde L, Van den Bergh PY, Penta M, Thonnard JL. Validation of the ABILHAND questionnaire to measure manual ability in children and adults with neuromuscular disorders. *J Neurol Neurosurg Psychiatry*. 2010;81: 506-12.
7. Klingels K, Mayhew AG, Mazzone ES, Duong T, Decostre V, Werlauff U et al. Development of a patient-reported outcome measure for upper limb function in Duchenne muscular dystrophy: DMD Upper Limb PROM. *Dev Med Child Neurol*. 2017; 59(2):224-31.
8. Butler EE, Ladd AL, Louie SA, LaMont LE, Wong W, Rose J. Three-dimensional kinematics of the upper limb during a reach and grasp cycle for children. *Gait Posture*. 2010;32(1):72-7.
9. Mazzone ES, Vasco G, Palermo C, Bianco F, Galluccio C, Ricotti V, Castronovo AD, Mauro MS, Pane M, Mayhew A, Mercuri E. A critical review of functional assessment tools for upper limbs in Duchenne muscular dystrophy. *Dev Med Child Neurol*. 2012; 54(10):879-85.
10. Beenakker EA, Maurits NM, Fock JM, Brouwer OF, Van der Hoeven JH. Functional ability and muscle force in healthy children and ambulant Duchenne muscular dystrophy patients. *Eur J Paediatr Neurol*. 2005; 9:387-93.
11. Martini J, Voos MC, Hukuda ME, Resende MBD, Caromano FA. Compensatory movements during functional activities in ambulatory children with Duchenne muscular dystrophy. *Arq Neuropsiquiatr*. 2014;72: 5-11.

12. Voos M, Favero F, Dias K, Artiheiro M, Oliveira A, Caromano F. Dissociation between motor and cognitive skills in patients with Duchenne muscular dystrophy. *Neuromuscul Disord*. 2015; 25 (Suppl 2):S306.
13. Vignos, PJ Jr, Spencer GE Jr, Archibald KC. Management progressive muscular dystrophy of childhood. *JAMA*. 1963; 184:89-96.
14. Folstein MF, Folstein SE, McHugh PR. Mini-Mental State: a practical method for grading the cognitive state of patients for clinician. *J Psychiatr Res*. 1975; 12:189-98.
15. Oldfield RC. The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychol*. 1971; 9(1):97-113.
16. Elwardany SH, El-Sayed WH, Ali MF. Reliability of Kinovea Computer Program in Measuring Cervical Range of Motion in Sagittal Plane. *OALib Journal*. 2015; 2:1-10.
17. Berben L, Sereika SM, Engberg S. Effect size estimation: Methods and examples. *Int J Nurs Stud*. 2012, 49:1039-47.
18. Rosenthal JA. Qualitative descriptors of strength of association and effect size. *J Soc Serv Res*. 1996, 21:37-59.
19. Hogrel JY, Wary C, Moraux A, Azzabou N, Decostre V, Ollivier G, et al. Longitudinal functional and NMR assessment of upper limbs in Duchenne muscular dystrophy. *Neurology*. 2016; 86(11):1022-30.
20. Janssen MM, Harlaar J, de Groot IJ. Surface EMG to assess arm function in boys with DMD: a pilot study. *J Electromyogr Kinesiol*. 2015; 25(2):323-28.

21. Artilheiro MC, Corrêa JC, Cimolin V, Lima MO, Galli M, de Godoy W, Lucareli PR. Three-dimensional analysis of performance of an upper limb functional task among adults with dyskinetic cerebral palsy. *Gait Posture*. 2014; 39(3):875-81.
22. Artilheiro MC, Cardoso de Sá CD, Fávero FM, Wutzki HC, de Resende MB, Caromano FA, Voos MC. Hand Function in Muscular Dystrophies. *Percept Mot Skills*. 2017; 124(2):441-51.
23. Han JJ, de Bie E, Nicorici A, Abresch RT, Anthonisen C, Bajcsy R, Kurillo G, McDonald CM. Reachable workspace and performance of upper limb (PUL) in duchenne muscular dystrophy. *Muscle Nerve*. 2016; 53(4):545-54.

Table 1 – Characteristics of DMD patients (N=26) and controls (N=22)

	Group	Age (years)	Dominance	Vignos	Ambulation	MMSE
1	DMD	13	D	1	Present	28
2	DMD	16	D	8	Absent	28
3	DMD	20	D	8	Absent	28
4	DMD	16	D	8	Absent	28
5	DMD	17	E	7	Absent	26
6	DMD	11	D	1	Present	13
7	DMD	13	D	2	Present	30
8	DMD	13	D	3	Present	24
9	DMD	15	D	7	Absent	30
10	DMD	16	D	8	Absent	9
11	DMD	23	D	7	Absent	27
12	DMD	21	D	7	Absent	29
13	DMD	13	D	7	Absent	8
14	DMD	13	D	7	Absent	26
15	DMD	12	E	7	Absent	29
16	DMD	16	D	7	Absent	28
17	DMD	12	D	4	Present	28
18	DMD	12	E	2	Present	26
19	DMD	13	D	7	Absent	17
20	DMD	9	D	7	Absent	10
21	DMD	8	D	8	Absent	27
22	DMD	11	E	7	Absent	29
23	DMD	12	D	5	Present	28
24	DMD	12	D	8	Absent	19
25	DMD	9	D	7	Absent	28
26	DMD	13	D	4	Present	19
	26	13.81±3.59	R: 22;L: 4	5.92±2.33	P: 6; A:18	23.92±6.93
1	Control	15	D	.	Present	.
2	Control	13	D	.	Present	.
3	Control	17	E	.	Present	.
4	Control	11	D	.	Present	.
5	Control	23	D	.	Present	.
6	Control	16	D	.	Present	.
7	Control	16	D	.	Present	.
8	Control	26	D	.	Present	.
9	Control	21	D	.	Present	.
10	Control	29	D	.	Present	.
11	Control	13	D	.	Present	.
12	Control	19	D	.	Present	.
13	Control	25	D	.	Present	.
14	Control	20	D	.	Present	.
15	Control	25	D	.	Present	.
16	Control	23	D	.	Present	.
17	Control	28	D	.	Present	.
18	Control	20	D	.	Present	.
19	Control	18	E	.	Present	.
20	Control	34	D	.	Present	.
21	Control	25	D	.	Present	.
22	Control	23	D	.	Present	.
	22	21±5.82	R: 20; L: 2	-	P: 22	-

Figure 1 - DMD patient performing initial and final angles of bringing the spoon to the mouth to simulate feeding. A: picking one bean with a spoon; B: bringing the spoon to the mouth.

Figure 2 - Elbow and head flexion in patients with Duchenne muscular dystrophy (DMD) and controls ($F(1,46) = 13.618$; $P=0.0006$). Elbow and head initial and final angles of patients with DMD and controls are expressed in means and 95% confidence intervals. We considered elbow complete extension as zero degrees. Head neutral position was also considered as zero degrees (no flexion and no extension).

Figure 3 - Time parameters of patients with DMD and controls ($F(1,46) = 18.804$; $P=0.00008$) and peak velocity ($F(1,46) = 1.6392$; $P=0.207$). The data of Duchenne Muscular Dystrophy patients and Controls are expressed in mean and 0.95 confidence intervals.

GENERAL DISCUSSION

The four articles presented in this thesis are prospective observational studies. Three of them had a cross-sectional methodological design and one had a case-control design. The methodological process was based on the essential items that should be described in observational studies, according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement³⁶. In all articles, the upper limbs performance was assessed by video observation, which represents a simple and inexpensive clinical tool. The possibility of scoring functional tasks by posterior film observation encourages the use of quantitative assessment in clinical practice. Besides, this method is reproducible and accessible.

Timed performance of functional tasks can be measured in a physical therapy session or later, by using kinematic analysis. Recent studies stated that timed performance can be used to monitor the impact of muscle weakness progression in patients with Duchenne muscular dystrophy^{29,37-38}.

The Jebsen-Taylor Test represents the only upper limb assessment protocol that uses exclusively time as a functional measure. The application and comparison of the Jebsen-Taylor Test with the gold standard tool to measure upper limbs function in Duchenne muscular dystrophy (Performance of Upper Limb) found strong correlation between total and partial scores. These findings indicate that timed performance and motor function are correlated, as previously verified in functional tasks involving the trunk and the lower limbs²⁹.

The first study contributes with strategies for selecting the test to evaluate patients with DMD in clinical practice. The Jebsen-Taylor test and the Performance of Upper Limb measure function by distinct clinical strategies: timed performance and clinical tasks scoring. The therapist should choose the test based on the patient and/or caregiver clinical main issue. If the patient reports the requirement of longer time to perform upper limbs daily activities, we suggest the assessment with the Jebsen-Taylor Test. If the priority is evaluating specific kinesiological characteristics of the shoulder, elbow and/or wrist, we suggest the Performance of Upper Limb protocol. The selection of the most suitable test prevents the patient's exposure to long-term assessment procedures, decreases muscle effort and, mostly, facilitates finding the answers based on clinical reasoning.

In the second study, we investigated the relationship between the dominant and the non-dominant upper limbs by evaluating timed performance. The strong correlation found between upper limbs performance in patients with Duchenne muscular dystrophy showed that evaluating both upper limbs may generate redundant measures. Besides, extensive protocols must count on time availability of therapists and patients and may cause fatigue in DMD patients.

We hypothesized that asymmetry would be less evident at the early stages of DMD, and consequently more evident in the late stages. No relationship was found between limb asymmetry and Vignos Score, neither between asymmetry and age, which showed that the asymmetry does not change as DMD progresses. Timed performance was correlated to upper limb motor function (assessed by the dimension 3 of Motor Function Measure) and to proximal and distal upper limb muscle strength (resulted from the Medical

Research Council index). A recent study found a strong correlation between muscle strength and motor function³⁹. The authors also pointed out that muscle strength and motor function losses are associated in Duchenne muscular dystrophy progression.

The Jebsen-Taylor Test consists in tasks with a specific purpose or goal which require motor reprogramming when holding the spoon, picking up the beans and transporting them, i.e., in a closed-loop condition. During closed-loop tasks, cognitive and attentional demands are necessary. The findings of the studies indicate that this condition demands central motor programming and requires greater muscle demand compared to open-loop conditions, such as in the act of simulating movements⁴⁰. Assessment protocols should reproduce real conditions, with similar planning and control demands of the voluntary movements according to the task, the context and the environment⁴¹.

The third study analyzed the psychometric properties of the Jebsen-Taylor Test. The study showed that the test was a reliable and valid measure of upper limb timed performance in Duchenne muscular dystrophy. The performance of a group of patients with muscular dystrophies showed very high interrater reliability, as well as good internal consistency. Therefore, the Jebsen-Taylor Test is also valid for measuring timed performance in patients with other types of muscular dystrophy. Correlations between the Jebsen-Taylor Test and the gold standard measure used to assess upper limb function in Duchenne Muscular Dystrophy (Performance of Upper Limb) were found. Good psychometric properties indicated that timed performance can be used to measure the progression of muscle weakness and upper limb function in patients with muscular dystrophy.

The timed performance analysis showed increased time in non-ambulatory in comparison with ambulatory patients. The subtests turning over cards, picking up small common objects and picking up large light objects were more sensitive to detect differences in upper limb performance between non-ambulatory and ambulatory patients. Simulating feeding detected differences in the upper limb performance between non-ambulatory and ambulatory patients with Duchenne muscular dystrophy, whereas stacking checkers revealed differences in the upper limb performance between non-ambulatory and ambulatory patients with other types of muscular dystrophy.

The third study also provided reference values of timed performance for ambulatory and non-ambulatory patients with Duchenne muscular dystrophy and other muscular dystrophy types. The description of timed performance and the establishment of performance categories is useful for monitoring the progression of muscle weakness in research and clinical practices.

Hiller and Wade³¹ affirm that short times to complete the subtests of the Jebsen-Taylor Test may be indicative of upper limb muscle strength preservation in boys with Duchenne muscular dystrophy. Increased time in comparison with normative values of healthy individuals⁴² are not only related to the progression of muscle weakness, but also to the presence of compensatory movements. The compensatory movements can result in increased variability and different ways of performing the same functional task.

Assessing the impairment of compensatory movements on functionality is essential, since functional abilities are not only affected by muscle weakness^{7,35}. Upper limb function is directly correlated to the ability of performing daily activities, such as feeding. The fourth article analyzed the

angular and temporal kinematic parameters of the movement of bringing a spoon to the mouth. The study compared the performance of patients with Duchenne muscular dystrophy and healthy controls and described the compensatory movements adopted to perform the functional task.

Ambulatory and non-ambulatory patients were able to perform the movement of bringing a spoon to the mouth. The decrease of elbow flexion angle and the increase of head flexion showed that compensatory movements decreased the elbow flexion concentric contraction requirement and compensated for the weakness of the upper limb. The increased time can also be considered as a strategy to compensate muscle weakness. Despite of high variability of movements and performance, we believe the adoption of compensatory movements helps maintaining the function and prevents the loss of functional abilities.

The clinical practice of physical and occupational therapists should recognize the presence of these strategies to choose the best approach for assessment and training of feeding, or even similar movements, such as hand or transporting of other utensils to the mouth. The assessment of compensatory movements combined to timed performance provides relevant information about motor function and can also be used to monitor functional progression.

The combination of timed performance and quantitative assessment of compensatory movements represents the ideal protocol of upper limb function assessment in muscular dystrophy. Future studies should use the suggested protocol to explore other functional tasks involving hygiene and clothing.

We included in the first and third studies patients with other forms of muscular dystrophies besides Duchenne or Becker muscular dystrophies. In the

second and fourth studies, we included patients with Duchenne or Becker muscular dystrophies, who were ambulatory and non-ambulatory. However, the clinical heterogeneity is inherent of muscular dystrophies population, characterized by clinical and phenotypic variability^{14,43}.

This thesis proposes that timed performance should be included in upper limb function protocols. This expands the knowledge about the upper limbs assessment in patients with Duchenne muscular dystrophy. We believe that the search for instruments and specific methods of evaluation is the starting point for evaluating functional outcomes, recommending therapeutic exercises, indicating orthotic devices and/or surgical interventions, developing strengthening and resistance muscle training programs^{8,11,44}. The assessment of timed performance may also contribute to detect the effects of new drugs and genetic therapies, interventions that has been increasing in the recent years⁴⁵.

The study of the assessment of upper limb motor function will not be ended in this current phase. Future studies should follow the functional changes to describe the whole spectrum of upper limb function in Duchenne muscular dystrophy.

FINAL CONSIDERATIONS

1. People with Duchenne muscular dystrophy are not more asymmetrical than healthy subjects.
2. Upper limbs performances are strongly correlated; therefore, the therapist can infer the non-dominant limb performance based on the dominant limb performance or vice versa in most patients with DMD.
3. The Jebsen-Taylor Test showed high interrater reliability and good internal consistence.
4. The Jebsen-Taylor Test is valid to measure upper limb timed performance.
5. The Jebsen-Taylor Test is strongly correlated to the Performance of Upper Limb and both precisely measure function by timed performance and kinesiologic characteristics descriptions in patients with Duchenne and Becker muscular dystrophies.
6. Timed performance, motor function and muscle strength of upper limbs are correlated in patients with Duchenne muscular dystrophy.
7. Many compensatory movements were observed in upper limb functional tasks in all stages of Duchenne muscular dystrophy.
8. Patients with Duchenne muscular dystrophy performed bringing the spoon to the mouth with decreased elbow flexion and increased head flexion in order to compensate elbow flexors weakness.
9. The assessment of compensatory movements provides relevant information for motor function and DMD progression.

10. Quantitative clinical tests contribute to the knowledge and to the measurement of therapeutic outcomes and enable monitoring the progression of upper limbs function in patients with Duchenne muscular dystrophy.

REFERÊNCIAS BIBLIOGRÁFICAS

1. Mercuri E, Muntoni F. Muscular dystrophies. *Lancet*. 2013; 381(9869):845-60.
2. Romitti PA, Zhu Y, Puzhankara S, James KA, Nabukera SK, Zamba GK, Ciafaloni E, Cunniff C, Druschel CM, Mathews KD, Matthews DJ, Meaney FJ, Andrews JG, Conway KM, Fox DJ, Street N, Adams MM, Bolen J; MD STARnet. Prevalence of Duchenne and Becker muscular dystrophies in the United States. *Pediatrics*. 2015;135(3): 513-21.
3. van den Bergen JC, Wokke BH, Hulsker MA, Verschuuren JJ, Aartsma-Rus AM. Studying the role of dystrophin-associated proteins in influencing Becker muscular dystrophy disease severity. *Neuromuscul Disord*. 2015; 25(3):231-7.
4. Lacourpaille L, Hug F, Guével A, Péréon Y, Magot A, Hogrel JY, Nordez A. New insights on contraction efficiency in patients with Duchenne muscular dystrophy. *J Appl Physiol*. 2014; 117(6):658-62.
5. Head SI, Williams DA, Stephenson DG. Abnormalities in structure and function of limb skeletal muscle fibres of dystrophic mdx mice. *Proc Biol Sci*. 1992; 248(1322):163-9.
6. Muntoni F, Torelli S, Ferlini A. Dystrophin and mutations: one gene, several proteins, multiple phenotypes. *Lancet Neurol*. 2003; 2(12):731-40.
7. Mazzone ES, Vasco G, Palermo C, Bianco F, Galluccio C, Ricotti V, Castronovo AD, Mauro MS, Pane M, Mayhew A, Mercuri E. A critical

- review of functional assessment tools for upper limbs in Duchenne muscular dystrophy. *Dev Med Child Neurol*. 2012;54(10):879-85.
8. Janssen MM, Bergsma A, Geurts AC, de Groot IJJ Neurol. Patterns of decline in upper limb function of boys and men with DMD: an international survey. *J Neurol*. 2014; 261(7):1269-88.
 9. Kohler M, Clarenbach CF, Bahler C, Brack T, Russi EW, Bloch KE. Disability and survival in Duchenne muscular dystrophy. *J Neurol Neurosurg Psychiatry*. 2009; 80:320-25.
 10. Mayhew A, Mazzone ES, Eagle M, Duong T, Ash M, Decostre V et al. Development of the performance of the upper limb module for Duchenne muscular dystrophy. *Dev Med Child Neurol*. 2013; 55:1038-45.
 11. Alemdaroğlu I, Karaduman A, Yilmaz ÖT, Topaloğlu H. Different types of upper extremity exercise training in Duchenne muscular dystrophy: effects on functional performance, strength, endurance, and ambulation. *Muscle Nerve*. 2015; 51(5):697-705.
 12. Klingels K, Mayhew AG, Mazzone ES, Duong T, Decostre V, Werlauff U et al. Development of a patient-reported outcome measure for upper limb function in Duchenne muscular dystrophy: DMD Upper Limb PROM. *Dev Med Child Neurol*. 2017; 59(2):224-31.
 13. Mercuri E, McDonald C, Mayhew A, Florence J, Mazzone E, Bianco F, Decostre V, Servais L, Ricotti V, Goemans N, Vroom E. International workshop on assessment of upper limb function in Duchenne Muscular Dystrophy: Rome, 15-16 February 2012. *Neuromuscul Disord*. 2012; 22(11):1025-8.

14. Servais L, Deconinck N, Moraux A, Benali M, Canal A, Van Parys F et al. Innovative methods to assess upper limb strength and function in non-ambulant Duchenne patients. *Neuromuscul Disord*. 2013; 23(2):139-48.
15. Stübgen JP, Stipp A. Facioscapulohumeral muscular dystrophy: a prospective study of weakness and functional impairment. *Neurol*. 2010; 257(9):1457-64
16. Mercuri E, Mayhew A, Muntoni F, Messina S, Straub V, Van Ommen GL et al. Towards harmonization of outcome measures for DMD and SMA within TREAT-NMD; report of 3 expert workshops: TREAT-NMD/ ENMC workshop on outcome measures, 12th-13th May 2007, Naarden, The Netherlands; TREAT-NMD workshop on outcome measures in experimental trials for DMD, 30th June-1st July 2007, Naarden, The Netherlands; conjoint Institute of Myology TREAT-NMD meeting on physical activity monitoring in neuromuscular disorders, 11th July 2007, Paris, France. *Neuromuscul Disord* 2008; 18:894-903.
17. Vandervelde L, Van den Bergh PY, Goemans N, Thonnard JL. ACTIVLIM: a Rasch-built measure of activity limitations in children and adults with neuromuscular disorders. *Neuromuscul Disord*. 2007;17(6): 459-66.
18. Vandervelde L, Van den Bergh PY, Penta M, Thonnard JL. Validation of the ABILHAND questionnaire to measure manual ability in children and adults with neuromuscular disorders. *J Neurol Neurosurg Psychiatry*. 2010; 81:506-512.
19. Janssen MMHP, Geurts ACH, de Groot IJM. Towards a short questionnaire for stepwise assessment of upper limb function, pain and

- stiffness in Duchenne muscular dystrophy. *Disabil Rehabil.* 2018; 40(7):842-7.
20. Lue YJ, Su CY, Yang RC, Su WL, Lu YM, Lin RF, Chen SS. Development and validation of a muscular dystrophy-specific functional rating scale. *Clin Rehabil.* 2006; 20(9):804-17.
21. Brooke MH, Griggs RC, Mendell JR, Fenichel GM, Shumate JB, Pellegrino RJ. Clinical trial in Duchenne dystrophy. I. The design of the protocol. *Muscle Nerve.* 1981; 4(3):186-97.
22. Iwabe C, Miranda-Pfeilsticker BH, Nucci A. Medida da função motora: versão da escala para o português e estudo de confiabilidade. *Rev Bras Fisioter.* 2008; 12(5): 417-24.
23. Bérard C, Payan C, Hodgkinson I, Fermanian J. A motor function measure scale for neuromuscular diseases. Construction and validation study. *Neuromuscular Disord.* 2005; 15:463-70.
24. Bérard C, Payan C, Fermanian J, Girardot F, Groupe d'Etude MFM. A motor function measurement scale for neuromuscular disease - description and validation study. *Rev Neurol.* 2006; 162:485-93.
25. Bartels B, Pangalila RF, Bergen MP, Cobben NAM, Stam HJ, Roebroek ME. Upper limb function in adults with Duchenne muscular dystrophy. *J Rehabil Med.* 2011; 43:12-7.
26. Pane M, Mazzone ES, Fanelli L, De Sanctis R, Bianco F, Sivo S, D'Amico A, Messina S, Battini R, Scutifero M, Petillo R, Frosini S, Scalise R, Vita G, Bruno C, Pedemonte M, Mongini T, Pegoraro E, Brustia F, Gardani A, Berardinelli A, Lanzillotta V, Viggiano

- E, Cavallaro F, Sframeli M, Bello L, Barp A, Bonfiglio S, Rolle E, Colia G, Catteruccia M, Palermo C, D'Angelo G, Pini A, Iotti E, Gorni K, Baranello G, Morandi L, Bertini E, Politano L, Sormani M, Mercuri E. Reliability of the Performance of Upper Limb assessment in Duchenne muscular dystrophy. *Neuromuscul Disord.* 2014; 24(3): 201-6.
27. Pane M, Fanelli L, Mazzone ES, Olivieri G, D'Amico Adele, Messina S, Scutifero M, Battini R, Petillo R, Frosini S, Sivo S, Vita GL, Bruno C, Mongini T, Pegoraro E, De Sanctis R, Gardani A, Berardinelli A, Lanzillotta V, Carlesi A, Viggiano E, Cavallaro F, Sframeli M, Bello L, Barp A, Bianco F, Bonfiglio S, Rolle E, Palermo C, D'Angelo G, Pini A, Lotti E, Gorni K, Baranello G, Bertini E, Politano L, Sormani MP, Mercuri E. Benefits of glucocorticoids in non-ambulant boys/men with Duchenne muscular dystrophy: A multicentric longitudinal study using the Performance of Upper Limb test. *Neuromuscul Disord.* 2015; 25(10):749-53.
28. Beenakker EA, Maurits NM, Fock JM, Brouwer OF, van der Hoeven JH. Functional ability and muscle force in healthy children and ambulant Duchenne muscular dystrophy patients. *Eur J Paediatr Neurol.* 2005;9: 387-93.
29. Martini J, Hukuda ME, Caromano FA, Favero FM, Fu C, Voos MC. The clinical relevance of timed motor performance in children with Duchenne muscular dystrophy. *Physiother Theory Pract.* 2015; 31(3):173-81.

30. Jebsen RH, Taylor N, Trieckmann RB, Trotter MJ, Howard LA. An objective and standardized test of hand function. *Arch Phys Med Rehabil.* 1969;50: 311-19.
31. Hiller LB, Wade CK. Upper extremity functional assessment scales in children with Duchenne muscular dystrophy: a comparison. *Arch Phys Med Rehabil.* 1992; 73:527-34.
32. Artilheiro MC¹, Cardoso de Sá CD², Fávero FM³, Wutzki HC⁴, de Resende MB⁴, Caromano FA¹, Voos MC¹. Hand Function in Muscular Dystrophies. *Percept Mot Skills.* 2017; 124(2):441-51.
33. Artilheiro MC, de Sá CSC, Fávero FM, Caromano FA, Voos MC. Patients with duchenne and becker muscular dystrophies are not more asymmetrical than healthy controls on functional timed upper limbs tasks. *Braz J Med Biol Res.* 2017; xx: xx-xx.
34. Lowes LP, Alfano LN, Smigelsi J, Mendell JR, Flanigan KF. SP 11 Development of a virtual upper extremity assessment tool for individuals with DMD across the lifespan. *Neuromuscul Disord.* 2012; 22:878-79.
35. Kurillo G, Han JJ, Abresch RT, Nicorici A, Yan P, Bajcsy R. Development and application of stereo camera-based upper extremity workspace evaluation in patients with neuromuscular diseases. *PloS One.* 2012;1-10.
36. Vandembroucke JP, von Elm E, Altman DG, Gøtzsche PC, Mulrow CD, Pocock SJ, Poole C, Schlesselman JJ, Egger M; STROBE Initiative. Strengthening the Reporting of Observational Studies in Epidemiology

- (STROBE): explanation and elaboration. *Epidemiology*. 2007;18(6):805-35.
37. Mazzone ES, Coratti G, Sormani MP, Messina S, Pane M, D'Amico A, Colia G, Fanelli L, Berardinelli A, Gardani A, Lanzillotta V, D'Ambrosio P, Petillo R, Cavallaro F, Frosini S, Bello L, Bonfiglio S, De Sanctis R, Rolle E, Forcina N, Magri F, Vita G, Palermo C, Donati MA, Procopio E, Arnoldi MT, Baranello G, Mongini T, Pini A, Battini R, Pegoraro E, Torrente Y, Previtali SC, Bruno C, Politano L, Comi GP, D'Angelo MG, Bertini E, Mercuri E. Timed Rise from Floor as a Predictor of Disease Progression in Duchenne Muscular Dystrophy: An Observational Study. *PLoS One*. 2016; 11(3):1-9.
38. McDonald CM, Henricson EK, Abresch RT, Florence JM, Eagle M, Gappmaier E, Glanzman AM; PTC124-GD-007-DMD Study Group, Spiegel R, Barth J, Elfring G, Reha A, Peltz S. The 6-minute walk test and other endpoints in Duchenne muscular dystrophy: longitudinal natural history observations over 48 weeks from a multicenter study. *Muscle Nerve*. 2013; 48(3):343-56.
39. Nunes MF, Hukuda ME, Favero FM, Oliveira AB, Voos MC, Caromano FA. Relationship between muscle strength and motor function in Duchenne muscular dystrophy. *Arq Neuropsiquiatr*. 2016; 74(7):530-5.
40. McKay JL, Ting LH. Optimization of muscle activity for task-level goals predicts complex changes in limb forces across biomechanical contexts. *PLoS Comput Biol*. 2012; 8(4):1-17.

41. Holt KG, Wagenaar RO, Saltzman E. A dynamic systems/constraints approach to rehabilitation. *Braz J Phys Ther.* 2010; 14(6):446-63.
42. Sarafraz Z, Vahedi Z. Hand function related to Age and Sex. *Iran Rehab J.* 2008; 6(7):10-15.
43. Connolly AM, Malkus EC, Mendell JR, Flanigan KM, Miller JP, Schierbecker JR, Siener CA, Golumbek PT, Zaidman CM, McDonald CM, Johnson L, Nicorici A, Karachunski PI, Day JW, Kelecic JM, Lowes LP, Alfano LN, Darras BT, Kang PB, Quigley J, Pasternak AE, Florence JM; MDA DMD Clinical Research Network Outcome reliability in non-ambulatory boys/men with Duchenne muscular dystrophy. *Muscle Nerve.* 2015;51(4):522-32.
44. Hogrel JY, Wary C, Moraux A, Azzabou N, Decostre V, Ollivier G, Canal A, Lilien C, Ledoux I, Annoussamy M, Reguiba N, Gidaro T, Le Moing AG, Cardas R, Voit T, Carlier PG, Servais L. Longitudinal functional and NMR assessment of upper limbs in Duchenne muscular dystrophy. *Neurology.* 2016; 86(11):1022-30.
45. Leigh F, Ferlini A, Biggar D, Bushby K, Finkel R, Morgenroth LP, Wagner KR. Neurology Care, Diagnostics, and Emerging Therapies of the Patient With Duchenne Muscular Dystrophy. *Pediatrics.* 2018; 142(Suppl 2):S5-S16.

ANEXOS

Anexo 1 – Projeto de Pesquisa

Resumo

Introdução: A avaliação específica e completa da função de membros superiores e da cognição pode contribuir para a análise contínua da progressão e permitir ao fisioterapeuta quantificar as alterações e elaborar um plano de tratamento específico para pacientes com Distrofia Muscular de Duchenne.

Objetivo: Avaliar a função dos membros superiores e a função cognitiva de pacientes com Distrofia Muscular de Duchenne por meio de instrumentos de avaliação específicos. **Método:** 50 pacientes com Distrofia Muscular de Duchenne que compuserão o grupo experimental e 50 indivíduos saudáveis pareados que compuserão o grupo controle serão submetidos a uma bateria de avaliação motora e cognitiva. A avaliação da função motora dos membros superiores será composta pela determinação da dominância manual e da aplicação da Medida de Função Motora, do Teste de Jebsen-Taylor e do Teste Performance of Upper Limb. Para a avaliação cognitiva, o Mini Exame do Estado Mental, o Teste do Relógio, o Teste de Fluência verbal e semântica e o Teste Ordem de Dígitos serão aplicados. Todos os voluntários executarão os testes em um único momento de avaliação, por um único avaliador treinado para aplicação dos mesmos. **Análise estatística:** O teste de Kolmogorov-Smirnov será aplicado para a verificação da distribuição das variáveis analisadas de acordo com a Curva de Gauss. Para a comparação dos testes de função de membros superior e da função cognitiva do grupo experimental, será utilizado o teste ANOVA One-way, complementado pelo teste de

comparações múltiplas de Tukey. As diferenças entre as pontuações dos grupos experimental e controle serão analisadas por meio do Teste T de Student.

Introdução

As distrofias musculares (DM) são um grupo de desordens heterogêneas geneticamente determinadas, identificadas clinicamente por grande variabilidade do fenótipo e de gravidade e caracterizadas por fraqueza muscular.⁽¹⁻⁴⁾

A maioria delas compartilha a mesma característica patológica. Conforme o curso da doença, o tecido muscular sofre lesões que acarretam em formação de fibrose e posteriormente o tecido muscular é substituído por gordura. No entanto, o mecanismo de evolução e a velocidade em que ele ocorre em cada uma das formas específicas pode variar.⁽⁴⁾

Devido a heterogeneidade, as características clínicas também apresentam variação, como a herança genética e a idade de início de acometimento. Podem apresentar início pré-natal ou na vida adulta, podem ser rapidamente progressivas ou estar associadas a períodos de estabilidade e podem acarretar em envolvimento de vários sistemas, incluindo cardíaco e sistema nervoso central.⁽⁴⁻⁵⁾

Avanços contínuos na área de imunohistoquímica e genética molecular a partir da década de noventa têm permitido precisão do diagnóstico e, em detrimento disto, a classificação específica de acordo com os defeitos genéticos moleculares.⁽¹⁻³⁾

A maioria destes envolve a disfunção proteínas associadas à membrana, do complexo distrofina-glicoproteínas associadas, que liga o citoesqueleto subsarcolemal à matriz extracelular do músculo esquelético, permitindo estabilização e reforço da membrana da fibra muscular. O déficit parcial ou total das proteínas estruturais resultará em fenótipos variados e características clínicas específicas a cada tipo de Distrofia Muscular.⁽⁶⁾

A degeneração progressiva da musculatura esquelética que acarreta na fraqueza e atrofia muscular e na instalação de contraturas e deformidades dos músculos do esqueleto axial, do cingulo escapular e dos membros superiores (MMSS) são características inerentes de todo o grupo de DM. Sabe-se que o grau do envolvimento e do prejuízo destas musculaturas pode variar⁽⁷⁻⁸⁾, contudo o acometimento específico do MS em cada uma das formas descritas da doença é pouco investigado.

Nas formas de Distrofia em que o cingulo escapular é acometido, como na Distrofia Muscular de Cinturas (DMC) e na Distrofia Fascio-escapulo-umeral (FSH), é descrita a dificuldade de realizar a abdução e a flexão de ombro, bem como de sustentar estes movimentos devido à fraqueza proximal da musculatura dos MMSS e à perda de estabilidade escapular.⁽⁸⁻⁹⁾

O acometimento dos MMSS nas DM varia de acordo com suas formas específicas. Na Distrofia Muscular de Duchenne (DMD) o déficit do MS não surge até o paciente perder a capacidade de deambulação e iniciar a locomoção por meio de cadeira de rodas⁽⁸⁾. Segundo Becker⁽¹⁰⁾, a fraqueza distal na DMD e na Distrofia Muscular de Becker (DMB) é pronunciada nos estágios avançados da doença, quando a fraqueza proximal atinge grau severo. Contudo, estudo recente⁽¹¹⁾ demonstrou que os sintomas do

comprometimento da musculatura distal de MMSS também podem iniciar concomitantemente à instalação da fraqueza muscular em membros inferiores, nos estágios iniciais e intermediários da doença.

No estágio mais avançado da doença e/ou na vida adulta há alta variabilidade na limitação da funcionalidade do MS na DMD, mas comumente observa-se prejuízo da função motora proximal e certa preservação da distal, o que é essencial para manipular objetos e dispositivos auxiliares e de grande importância no auxílio da execução das atividades de vida diária.⁽¹²⁻¹³⁾ A capacidade funcional, contudo, é rapidamente perdida com a progressão da diminuição da força muscular com o passar dos anos, dado este que permite estabelecer correlação positiva entre idade e força manual com repercussão na função do MS.^(11,14-15)

A avaliação da função dos MMSS nas DM representa uma ferramenta clínica útil e de grande importância para o conhecimento das limitações funcionais e para caracterizar a história natural desse grupo de doenças.⁽¹⁶⁻¹⁷⁾ Contudo, não se sabe se qualquer índice clínico da progressão da doença se correlaciona estritamente com o processo da doença. A determinação de mensurações apropriadas que refletem melhora ou estabilização na habilidade funcional é um desafio para os profissionais que acompanham os pacientes com estes tipos de doenças neuromusculares (DNM).⁽¹⁷⁻¹⁸⁾

Os instrumentos validados e aplicados na população de DM têm sido utilizados na avaliação da função motora dos MMSS, como os questionários *Activity Limitations in Patients with Neuromuscular Disorders* (ACTIVILIM) e ABILHAND, e as escalas *Muscular Dystrophy Functional Rating Scale*, Brooke e a Medida de Função Motora (MFM).

O ACTIVILIM é um questionário desenvolvido e validado para caracterizar o curso clínico e quantificar efeitos de tratamentos nas limitações funcionais de crianças e adultos com DNM. Contudo, não é específico para avaliação do membro superior.⁽¹⁹⁾ O questionário ABILHAND foi validado para mensurar a percepção de dificuldade do paciente em realizar atividades manuais de vida diária.⁽²⁰⁾

A *Muscular Dystrophy Functional Rating Scale* foi desenvolvida para mensurar o impacto funcional da DM.⁽²¹⁾ É composta pelos domínios mobilidade, atividades básicas de vida diária, função de MMSS e comprometimento. O domínio de função de MMSS é composto pela avaliação da manipulação de objetos acima da cabeça, carregar objetos, limpar a mesa, escrita, virar livros, pegar objetos pequenos e manipulação de objetos pequenos. Os demais domínios, porém, não são restritos aos MMSS.

A escala Brooke foi desenvolvida para avaliar a função da extremidade superior na DMD/DMB.⁽²²⁾ É uma de graduação 1 a 6, de acordo com a gravidade do acometimento. Porém, trata-se de uma escala subjetiva que não avalia de maneira específica a funcionalidade dos MMSS.

A MFM possui versão na língua portuguesa e objetiva avaliar quantitativamente a função motora de pacientes com DNM, incluindo as DM.⁽²³⁾ A escala possibilita a avaliação, de modo abrangente, das disfunções motoras proximais, distais e axiais, por meio 32 itens, incluindo avaliações estáticas e dinâmicas, divididas em três dimensões, sendo 13 itens da Dimensão 1, que avalia a posição em pé e as transferências, 12 itens da Dimensão 2, que avalia

função motora axial e proximal de MMSS e inferiores e 7 itens da Dimensão 3, que avalia a função motora distal, dos quais 6 são referentes aos MMSS.⁽²⁴⁻²⁵⁾

A Dimensão 3 da MFM é utilizada para avaliação da função de punho e mão, mas é uma medida que não é capaz de identificar a função motora individual de pacientes com função prejudicada do MS⁽¹³⁾, o que talvez não permita avaliar de maneira precisa a função manual. Dos seis itens que avaliam a função distal do MS, apenas um deles apresenta, além da pontuação qualitativa, a avaliação do tempo de execução. Testes que analisam o desempenho nas tarefas funcionais por meio do tempo dispendido para a execução são úteis para avaliar a habilidade funcional na DMD⁽²⁶⁾ e monitorar o prejuízo desta no decorrer da progressão da doença.

O Teste de Jebsen-Taylor (TJT) foi desenvolvido em 1969 com o objetivo de avaliar a função manual comumente utilizada nas atividades de vida diária e mensurar de maneira objetiva o desempenho em tarefas funcionais. Não avalia apenas o aspecto distal, pois também há exigência de atuação de região proximal de MMSS para a execução das tarefas. É composto por sete testes: escrita, virar cartão (simular o ato de virar a página), pegar pequenos objetos comuns, simular alimentação, pegar peças de jogo de dama, pegar objetos largos e leves e pegar objetos largos e com peso.⁽²⁷⁾

A validação em pacientes com hemiparesia secundária à Acidente Vascular Encefálico (AVE) ou Traumatismo Craniano, artrite reumatóide e lesão medular foi realizada⁽²⁷⁾ e sua principal aplicação em estudos nos últimos anos tem sido em pacientes com disfunção manual secundária ao AVE e à

lesão medular.⁽²⁸⁻³¹⁾ Possui tradução para a língua portuguesa e excelente confiabilidade intra e interexaminador.⁽³²⁾

Anteriormente foi utilizado em crianças com DMD, mas não foi validado para a população, tampouco para as demais formas de DM. Por ser um teste de aplicação rápida e capaz de documentar continuamente a habilidade de cada categoria da função manual testada por meio da avaliação quantitativa do tempo de execução da tarefa com utilização de cronômetro, é capaz de fornecer um método discriminativo da progressão do paciente ao longo do tempo na evolução clínica e durante o tratamento com uso de drogas específicas da doença.⁽³³⁾

Acredita-se que a aplicação destes instrumentos de avaliação dos aspectos motores, em conjunto à avaliação dos aspectos cognitivos, que podem estar alterados nas DM⁽³⁴⁻³⁸⁾, contribuam para a análise contínua da progressão da função manual na DM e possibilitem uma avaliação abrangente dos aspectos que envolvem a função manual.

A DMD, principalmente, é associada com déficits cognitivos leves a graves e baixo desempenho escolar, independente da deficiência muscular ou ambiente clínico.⁽³⁹⁾ Aproximadamente 75% dos pacientes apresentam coeficiente de inteligência (QI) abaixo de 75. Observa-se também atraso da linguagem.⁽⁴⁰⁻⁴¹⁾

Apesar de os pacientes apresentarem déficit cognitivo importante, não há dados na literatura de escalas ou testes específicos que avaliem a função cognitiva dessa população. Testes neuropsicológicos que auxiliam o diagnóstico precoce de processos demenciais podem ser utilizados para

avaliação cognitiva de pacientes com DMD. São de fácil aplicação e necessitam de relativamente pouco tempo para execução. Entre os principais testes estão Teste do Desenho do relógio (TDR), Mini-Exame do estado Mental (MEEM), Fluência Verbal e semântica (FV), Ordem de dígitos direta e inversa.⁽⁴²⁾

Existe necessidade de melhor investigar as alterações motora e cognitiva em pacientes com DMD e a repercussão das mesmas nas funções de MMSS. Isso permitirá que o fisioterapeuta descreva de forma sistematizada e quantifique as alterações e elabore um plano de tratamento apropriado e específico para os déficits motores e cognitivos apresentados.

Objetivos

Objetivo primário:

Avaliar a função dos membros superiores e a função cognitiva de pacientes com Distrofia Muscular de Duchenne por meio de instrumentos de avaliação específicos.

Objetivos secundários:

1. Comparar o desempenho da função dos membros superiores e da função cognitiva de pacientes com Distrofia Muscular de Duchenne com indivíduos saudáveis.

2. Verificar possíveis diferenças funcionais entre o membro superior dominante e não-dominante de pacientes com Distrofia Muscular de Duchenne.
3. Investigar a relação entre a função motora e a função cognitiva de pacientes com Distrofia Muscular de Duchenne.

Material e Método

Tipo de estudo

Estudo prospectivo observacional com desenho metodológico do tipo transversal. As coletas acontecerão no ambulatório de Fisioterapia do Hospital das clínicas de São Paulo – SP. Os voluntários serão selecionados por conveniência.

Amostra

Critérios de inclusão para o grupo experimental (pacientes):

- Voluntários portadores de DM dos tipos Duchenne e Becker com diagnóstico confirmado por exame imonohistoquímico e/ou biópsia muscular, que realizavam acompanhamento clínico na ABDIM;
- Voluntários que foram submetidos a procedimentos cirúrgicos prévios nos MMSS e/ou na coluna vertebral;
- Concordância na participação na pesquisa através da assinatura do Termo de Consentimento Livre e Esclarecido para menores de 18 anos de idade ou Termo de Assentimento para maiores de 18 anos de idade.

Critérios de inclusão para o grupo controle (indivíduos saudáveis):

- Indivíduos pareados por idade que apresentarem concordância na participação através da assinatura do Termo de Consentimento Livre e Esclarecido para menores de 18 anos de idade ou Termo de Assentimento para maiores de 18 anos de idade.

Critérios de exclusão para o grupo experimental (pacientes):

- Dificuldade para compreensão de comandos verbais simples;
 - Déficits visuais e/ou auditivos que impossibilitem a aplicação do protocolo de pesquisa;
 - Presença de doenças ortopédicas e/ou neurológicas associada;
 - Ausência de função manual.
- Critérios de exclusão para o grupo controle (indivíduos saudáveis):
- Presença de doenças ortopédicas e/ou neurológicas associada;

Procedimentos

A partir da aprovação do projeto pelo comitê de ética em pesquisa, se dará início a execução dos procedimentos. Um avaliador realizará a aplicação de todos os testes nos voluntários selecionados em apenas um único momento de avaliação e os voluntários serão avaliados quanto à função motora e cognitiva.

A dominância será avaliada por meio de questionamento e demonstração da realização de tarefas cotidianas de manuseio de objetos. A Escala Vignos⁽⁴⁴⁾ é uma escala de estadiamento clínico e foi utilizada com intuito de caracterizar os voluntários.

Seis itens da dimensão três da Medida de Função Motora serão aplicados

(17 ao 22) - dos sete itens do domínio, um foi excluído por ser específico para avaliação da função motora das extremidades de membros inferiores.

Cada item foi avaliado duas vezes e o melhor desempenho apresentado foi pontuado de 0 a 3, onde 0 se o voluntário não realizou; A pontuação mínima para os seis itens é de zero pontos, enquanto a máxima é de dezoito pontos.⁽⁴⁵⁻⁴⁶⁾

O TJT é composto de sete subtestes para avaliação da maioria dos componentes da função manual: Subteste 1: escrita; Subteste 2; Subteste 3; Subteste 4; Subteste 5: pegar peças de jogo de dama; Subteste 6: pegar objetos largos e leves; Subteste 7: pegar objetos largos e com peso.⁽⁴⁷⁻⁴⁸⁾

Todos os subtestes serão realizados na sequência estabelecida para os dois MMSS, com inicialização pelo membro não dominante⁽⁴⁷⁾. Uma tentativa de cada subteste para cada MS será solicitada. Cada tentativa será mensurada quantitativamente por meio de cronômetro e filmada em câmera de vídeo para posterior análise.

A PUL Test é composta pelos domínios de ombro, cotovelo e punho. A pontuação para cada domínio pode variar de 0 a 4 ou de 0 a 6, sendo 74 pontos o máximo que pode ser alcançado. Os voluntários serão submetidos à aplicação de todos os domínios do Teste para composição do escore total.⁽⁴⁹⁾

Para avaliação da função cognitiva, os seguintes testes serão aplicados. O Mini Exame do Estado Mental (MEEM) é um teste validado para a população brasileira (19) e criado para avaliar funções cognitivas específicas. A pontuação máxima do MEEM é 30 pontos.⁽⁵⁰⁾ O Teste do relógio é de fácil e rápida aplicação. Pode ser empregado na investigação de algumas habilidades cognitivas, tais como funções visuoespaciais, funções visuoespaciais,

representação simbólica e grafomotora, linguagem auditiva, memória semântica e funções executivas.⁽⁵¹⁾ O Teste de fluência verbal e semântica exige habilidades de organização, auto-regulação e memória operacional. O entrevistado deve nomear exemplares de uma determinada categoria semântica, como animais e palavras com a mesma letra, por um minuto, divididos em intervalos de 15 segundos.⁽⁵²⁾ O Teste Ordem de dígitos é uma das principais tarefas utilizadas na avaliação da memória de curto prazo, em que o examinador pede ao paciente que repita uma série de números (por exemplo: 2-5, 3-6-7). A primeira sequência começa com dois dígitos, após cada resposta correta, o examinador acrescenta um dígito na sequência seguinte. O teste é composto de duas partes, na ordem direta e inversa.⁽⁵³⁾

Análise de dados

Inicialmente, o teste de Kolmogorov-Smirnov será aplicado para a verificação da distribuição das variáveis analisadas de acordo com a Curva de Gauss. Para a comparação dos testes de função de membros superior e da função cognitiva do grupo experimental, será utilizado o teste ANOVA One-way, complementado pelo teste de comparações múltiplas de Tukey. As diferenças entre as pontuações dos grupos experimental e controle serão analisadas por meio do Teste T de Student. A comparação da função entre o membro superior dominante e não-dominante do grupos experimental e controle também serão analisadas por meio do Teste T de Student. A investigação entre desempenho cognitivo e motor dos voluntários serão feitas por meio do teste de correlação de Spearman ou Pearson para investigar possíveis relações entre variáveis cognitivas e motoras em cada grupo. Os

coeficientes de correlação foram classificados como fortes ($r > 0,70$) ou moderados ($0,40 < r < 0,70$)

Cronograma

Identificação da Etapa	Início (dd/mm/aaaa)	Término (dd/mm/aaaa)
envio ao comitê de ética	06/05/2016	31/05/2016
Espera da aprovação pelo comitê de ética	01/06/2016	30/06/2016
Coleta de dados	01/07/2016	30/11/2016
Planilhamento de dados e análise de resultados	01/11/2016	30/12/2016
Redação científica e envio para publicação	02/01/2017	31/01/2017

Referências Bibliográficas

- 1 Brooke MH. A selective review of muscular dystrophies. Annual Educational Program of the American Academy of Neurology. Update on Neuromuscular diseases. Toronto: American Academy of Neurology; 1999.
- 2 Brzustowicz LM, Lehner T, Castilla LH, Penchaszadeh GK, Wilhelmsen KC, Bushby KMD. Making sense of the limb-girdle muscular dystrophies. Brain. 1999;122: 1403-20.
- 3 North K. New perspectives in pediatric neuromuscular disorders. J Child Neurol 1999;14: 26-57.
- 4 Flanigan KM. The muscular dystrophies. Seminars in Neurology 2012; 32: 255–263.
- 5 Manzur AY, Muntoni F. Diagnosis and new treatments in muscular dystrophies. J. Neurol. Neurosurg. Psychiatry. 2009; 80: 706-714.

6 Reed UC. Doenças Neuromusculares. J Pediatr. 2002; 78 (Supl.1): S89-S103.

7 Grange RW, Call JA. Recommendations to define exercise prescription for Duchenne muscular dystrophy. Exercise Sports Sci Ver. 2007; 35: 12-17.

8 Copeland SA, Levy O, Warner GC, Dodenhoff RM. The Shoulder in Patients With Muscular Dystrophy. Clin Orthop Rel Res. 1999; 368: 80 – 91.

9 Straub V, Bushby K. Therapeutic Possibilities in the Autosomal Recessive Limb-Girdle Muscular Dystrophies. J Am Soc Exp NeuroTher. 2008; 5: 619 – 626.

10 Becker PE. Two new families of benign sex-linked recessive muscular dystrophy. Rev Can Biol. 1962; 21: 551-566.

11 Mattar FL, Claudia Sobreira C. Hand weakness in Duchenne muscular dystrophy and its relation to physical disability. NeuroM Disord. 2008; 18: 193–198.

12 Wagner MB, Vignos PJ, Carlozzi C, Hull AL. Duchenne muscular dystrophy: a study of wrist and hand function. Muscle Nerve. 1989; 12: 236–244.

13 Bartels B, Pangalila RF, Bergen MP, Cobben NAM, Stam HJ, Roebroek ME. Upper Limb Function in Adults with Duchenne Muscular Dystrophy. J Rehabil Med 2011; 43: 12-17.

14 Pellegrini N, Pelletier A, Orlikowski D, Lolierou C, Ruquet M, Raphael JC, Lofaso F. Hand versus mouth for call-bell activation by DMD and Becker patients. Neuromuscular Disorders. 2007;17(7):532-6.

- 15 Pellegrini N, Guillon B, Prigent H, Pellegrini M, Orlikovski D, Raphael JC, Lofaso F. Optimization of power wheelchair control for patients with severe Duchenne muscular dystrophy. *Neuromuscul Disord*. 2004;14(5):297-300.
- 16 Lord JP, Portwood MM, Lieberman JS, Fowler WM, Berck P. Upper extremity functional rating for patients with Duchenne Muscular Dystrophy. *Arch Phys Med Rehabil*. 1987; 68: 151 – 154.
- 17 Stubgen JP, Stipp A. Facioscapulohumeral muscular dystrophy: a prospective study of weakness and functional impairment. *J Neurol*. 2010; 257: 1457–1464.
- 18 Mercuri E, Mayhew A, Muntoni F, et al. Towards harmonisation of outcome measures for DMD and SMA within TREAT-NMD; report of three expert workshops: TREAT-NMD/ ENMC workshop on outcome measures, 12th-13th May 2007, Naarden, The Netherlands; TREAT-NMD workshop on outcome measures in experimental trials for DMD, 30th June-1st July 2007, Naarden, The Netherlands; conjoint Institute of Myology TREAT-NMD meeting on physical activity monitoring in neuromuscular disorders, 11th July 2007, Paris, France. *Neuromuscul Disord* 2008;18:894-903.
- 19 Vandervelde L, Van den Bergh PYK, Goemans N, Thonnard J. ACTIVLIM: a Rasch-built measure of activity limitations in children and adults with neuromuscular disorders. *Neuromuscular Disorders*. 2007; 17: 459-69.
- 20 Vandervelde L, van den Bergh PY, Penta M, Thonnard JL. Validation of the ABILHAND questionnaire to measure manual ability in children and adults with neuromuscular disorders. *J Neurol Neurosurg Psychiatry*. 2010; 81:506-12.

- 21 Lue YJ, Su CY, Yang RC, Su WL, Lu YM, Lin RF et al. Development and validation of muscular dystrophy - specific functional rating scale. *Clin Rehabil.* 2006; 20(9): 804-17.
- 22 Brooke MH, Griggs RC, Mendell JR, Fenichel GM, Shumate JB, Pellegrino RJ. Clinical Trial in Duchenne Dystrophy: I design of protocol. *Muscle Nerve.* 1981; 4: 186 – 197.
- 23 Iwabe C, Miranda-Pfeilsticker BH, Nucci A. Medida da função motora: versão da escala para o português e estudo de confiabilidade. *Rev Bras Fisioter.* 2008; 12 (5): 417-424.
- 24 Bérard C, Payan C, Hodgkinson I, Fermanian J. The MFM Collaborative Study Group. A motor function measure scale for neuromuscular diseases. Construction and validation study. *Neuromuscul Disord.* 2005;15(7): 463-70.
- 25 Bérard C, Payan C, Fermanian J, Girardot F, Groupe d'Etude MFM. A motor function measurement scale for neuromuscular disease - description and validation study. *Rev Neurol.* 2006; 162(4): 485-93.
- 26 Beenakker EA, Maurits NM, Fock JM, Brouwer OF, van der Hoeven JH. Functional ability and muscle force in healthy children and ambulant Duchenne muscular dystrophy patients. *Eur J Paediatr Neurol.* 2005; 9: 387-93.
- 27 Mayhew A, Mazzone ES, Eagle M, Duong T, Ash M, Decostre V et al. Development of the performance of the upper limb module for duchenne muscular dystrophy. *Dev Med Child Neurol* 2013;55:1038–1045.

- 28 Jebsen RH, Taylor N, Triechmann RB, Trotter MJ, Howard LA. An objective and standardized test of hand function. *Arch Phys Med Rehabil.* 1969; 50: 311-319.
- 29 Beekhuizen KS, Field-Fote EC. Massed practice versus massed practice with stimulation: effects on upper extremity function and cortical plasticity in individuals with incomplete cervical spinal cord injury. *Neurorehabil Neural Repair.* 2005;19(1): 33-45.
- 30 Conforto AB, Cohen LG, dos Santos RL, Scaff M, Marie SK. Effects of somatosensory stimulation on motor function in chronic cortico-subcortical strokes. *J Neurol.* 2007; 254(3): 333-9.
- 31 CW, Seo HJ, Cohen LG. Influence of electric somatosensory stimulation on paretic-hand function in chronic stroke. *Arch Phys Med Rehabil.* 2006; 87(3): 351.
- 32 Hummel F, Celnik P, Giraux P, Floel A, Wu WH, Gerloff C et al. Effects of non-invasive cortical stimulation on skilled motor function in chronic stroke. *Brain.* 2005; 128(3):490-9.
- 33 Ferreiro KN, Santos RL, Conforto AB. Psychometric properties of the Portuguese version of the Jebsen-Taylor test for adults with mild hemiparesis. *Rev Bras Fisioter.* 2010; 14 (5): 377-381.
- 34 Hiller LB, Wade CK. Upper extremity functional assessment scales in children with Duchenne Muscular Dystrophy: a comparison. *Arch Phys Med Rehabil.* 1992; 73: 527-534.

35 Mazzone E, Vasco G, Palermo C, Bianco F, Galluccio C, Ricotti V et al. A critical review of functional assessment tools for upper limbs in Duchenne muscular dystrophy. *Developmental Medicine & Child Neurology*. 2012; 54(10):879-85.

36 Pereira ND, Michaelsen SM, Menezes IS, Ovando AC, Lima RCM, Teixeira-Salmela LF. Confiabilidade da versão brasileira do Wolf Motor Function Test em adultos com hemiparesia. *Rev Bras Fisioter*. 2011; 15 (3): 257-65.

37 Taub E, Uswatte G, King DK, Morris D, Crago JE, Chatterjee A. A placebo-controlled trial of constraint-induced movement therapy for upper extremity after stroke. *Stroke*. 2006; 37(4): 1045-9.

38 Mento G, Tarantino V, Bisiacchi P. The Neuropsychological Profile of Infantile Duchenne Muscular Dystrophy. *The Clinical Neuropsychologist*. 2011; 25(8):1359-1377.

39 Cyrulnik SE, Fee RJ, Batchelder A, Kiefel J, Goldstein E, Hinton VJ. Cognitive and adaptive deficits in young children with Duchenne muscular dystrophy (DMD). *Journal of the International Neuropsychological Society*. 2008; 14, 853–861.

40 Salam EA, Abdel-Meguid IE, Shatla R, Korraa S. Evaluation of neural damage in Duchenne muscular dystrophy patients. *Acta Myol*. 2014;33(1):13-8.

41 Pirker S, Perju-Dumbrava L, Kovacs GG, Traub-Weidinger T, Pirker W. Progressive Dopamine Transporter Binding Loss in Autopsy-Confirmed Corticobasal Degeneration. *J Parkinsons Dis*. 2015.

- 42 Nardes F, Araujo AP, Ribeiro MG. Mental retardation in Duchenne muscular dystrophy. *J Pediatr (Rio J)*. 2012;88(1):6-16
- 43 Nicholson LV, Johnson MA, Bushby KM, Gardner-Medwin D, Curtis A, Ginjaar IB, et al. Integrated study of 100 patients with Xp21 linked muscular dystrophy using clinical, genetic, immunochemical, and histopathological data. Part 1. Trends across the clinical groups. *J Med Genet*. 1993;30(9):728-36.
- 44 Vignos, PJ Jr, Spencer GE Jr, Archibald KC. Management progressive muscular distrophy of childhood. *JAMA* 1963;184:89-96.
- 45 Lourenço RA, Veras RP. Mini-Exame do Estado Mental: características psicométricas em idosos ambulatoriais. *Rev Saúde Pública*. 2006;40(4):712-9.
- 46 Anthony JC, LeResche L, Niaz U, von Korff MR, Folstein MF. Limits of the 'Mini-Mental State' as a screening test for dementia and delirium among hospital patients. *Psychol Med*. 1982;12(2):397-408.
- 47 Jebsen RH, Taylor N, Trieckmann RB, Trotter MJ, Howard LA. An objective and standardized test of hand function. *Arch Phys Med Rehabil*. 1969; 50: 311-319.
- 48 Ferreiro KN, Santos RL, Conforto AB. Psychometric properties of the Portuguese version of the Jebsen-Taylor test for adults with mild hemiparesis. *Rev Bras Fisioter*. 2010; 14 (5): 377-381.
- 49 Mayhew A, Mazzone ES, Eagle M, Duong T, Ash M, Decostre V et al. Development of the performance of the upper limb module for duchenne muscular dystrophy. *Dev Med Child Neurol* 2013;55:1038–1045.

50 Brucki SM, Nitrini R, Caramelli P, Bertolucci PH, Okamoto IH. [Suggestions for utilization of the mini-mental state examination in Brazil]. *Arq Neuropsiquiatr*. 2003;61(3b):777-81.

51 Silva TBLd, Yassuda MS, Guimarães VV, Florindo AA. Verbal fluency and sociodemographic variables in the aging process: an epidemiological study. *Psicologia: Reflexão e Crítica*. 2011;24(4):739-46.

52 De Figueiredo VLM, Do Nascimento E. Desempenhos nas duas tarefas do subteste dígitos do WISC-III e do WAIS-III. *Psicol Teor Pesqu*. 2007;23:313-8.

53 Zach EC. Avaliação neuropsicológica de pacientes com distrofia muscular de Duchenne. 2009.

Anexo 2 - Aprovação do Projeto de Pesquisa

HOSPITAL DAS CLÍNICAS DA
FACULDADE DE MEDICINA DA
USP - HCFMUSP

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação da função do membro superior e da cognição em pacientes com Distrofia Muscular de Duchenne e indivíduos saudáveis

Pesquisador: Mariana Callii Voos

Área Temática:

Versão: 1

CAAE: 59820316.8.0000.0068

Instituição Proponente: HOSPITAL DAS CLINICAS DA FACULDADE DE MEDICINA DA U S P

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 1.755.008

Apresentação do Projeto:

Trata-se de um estudo prospectivo observacional transversal com 100 participantes, sendo 50 pacientes com Distrofia Muscular de Duchenne e 50 voluntários no grupo controle. Os pacientes serão recrutados do ambulatório de Fisioterapia do Hospital das Clínicas da FMUSP e serão submetidos a avaliações de função motora e cognitiva através de testes validados na literatura. Todos os participantes executarão os testes em um único momento de avaliação, por um único avaliador treinado para aplicação dos mesmos.

Segundo os autores, os critérios de inclusão para o grupo experimental (pacientes): portadores de DM dos tipos Duchenne e Becker com diagnóstico confirmado por exame imonohistoquímico e/ou biópsia muscular, que realizavam acompanhamento clínico na ABDIM; que realizaram procedimentos cirúrgicos prévios nos MMSS e/ou na coluna vertebral; Concordância na participação na pesquisa através da assinatura do Termo de Consentimento Livre e Esclarecido para menores de 18 anos de idade ou Termo de Assentimento para maiores de 18 anos de idade.

Crítérios para o grupo controle (indivíduos saudáveis): Indivíduos pareados por idade que apresentarem concordância na participação através da assinatura do Termo de Consentimento Livre e Esclarecido para menores de 18 anos de idade ou Termo de Assentimento para maiores de 18 anos de idade.

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Continuação do Parecer: 1.755.008

Os Critérios de Exclusão são: para o grupo experimental (pacientes): Dificuldade para compreensão de comandos verbais simples; Déficits visuais e/ou auditivos que impossibilitem a aplicação do protocolo de pesquisa; Presença de doenças ortopédicas e/ou neurológicas associada; Ausência de função manual. Para o grupo controle (indivíduos saudáveis): Presença de doenças ortopédicas e/ou neurológicas associada;

Objetivo da Pesquisa:

O principal objetivo da pesquisa segundo os autores, é avaliar a função dos membros superiores e a função cognitiva de pacientes com Distrofia Muscular de Duchenne por meio de instrumentos de avaliação específicos. E como objetivo secundário:

1. Comparar o desempenho da função dos membros superiores e da função cognitiva de pacientes com Distrofia Muscular de Duchenne e indivíduos saudáveis
2. Verificar possíveis diferenças funcionais entre o membro superior dominante e não-dominante de pacientes com Distrofia Muscular de Duchenne
3. Investigar a relação entre a função motora e a função cognitiva de pacientes com Distrofia Muscular de Duchenne

Avaliação dos Riscos e Benefícios:

Segundo os autores, o participante da pesquisa não terá prejuízos e não sofrerá nenhum dano físico ou desconforto durante a realização dos movimentos que terá que fazer durante a aplicação dos testes.

A aplicação do protocolo pode aumentar o conhecimento da função motora e cognitiva do voluntário, mas não haverá benefício direto para o mesmo.

O participante e seu familiar possuem o direito de saber sobre os resultados parciais das pesquisas, ou de resultados que sejam do conhecimento dos pesquisadores.

Comentários e Considerações sobre a Pesquisa:

O estudo é relevante e inovador pois permitirá uma melhor compreensão da distrofia Muscular de Duchenne com parâmetros validados. É adequado aos princípios científicos e éticos e respeita o participante da pesquisa.

Considerações sobre os Termos de apresentação obrigatória:

O TCLE está claro e bem redigido. Informa adequadamente a justificativa, os objetivos e o modo como os procedimentos serão realizados no estudo, assim como explica sobre riscos e benefícios e a assistência durante a pesquisa e garante liberdade de participação.

Endereço: Rua Ovídio Pires de Campos, 225 5º andar

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E-mail: cappelq.adm@hc.fm.usp.br

Continuação do Parecer: 1.755.008

Conclusões ou Pendências e Lista de Inadequações:

Aprovado

Considerações Finais a critério do CEP:

Em conformidade com a Resolução CNS nº 466/12 – cabe ao pesquisador: a) desenvolver o projeto conforme delineado; b) elaborar e apresentar relatórios parciais e final; c) apresentar dados solicitados pelo CEP, a qualquer momento; d) manter em arquivo sob sua guarda, por 5 anos da pesquisa, contendo fichas individuais e todos os demais documentos recomendados pelo CEP; e) encaminhar os resultados para publicação, com os devidos créditos aos pesquisadores associados e ao pessoal técnico participante do projeto; f) justificar perante ao CEP interrupção do projeto ou a não publicação dos resultados.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_711092.pdf	12/09/2016 18:49:29		Aceito
Outros	CadastroCappesq.pdf	12/09/2016 18:45:41	Mariana Callil Voos	Aceito
Folha de Rosto	FolhadeRosto.pdf	12/09/2016 18:43:28	Mariana Callil Voos	Aceito
Projeto Detalhado / Brochura Investigador	ProjetoHC2016.docx	04/09/2016 13:09:34	Mariana Callil Voos	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TermodeConsentimentoLivreeEsclarecido.docx	04/09/2016 13:08:38	Mariana Callil Voos	Aceito

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

SAO PAULO, 30 de Setembro de 2016

Assinado por:
ALFREDO JOSE MANSUR
(Coordenador)

Endereço: Rua Ovídio Pires de Campos, 225 5º andar
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Anexo 3 – Teste de Jebsen-Taylor e suas instruções traduzidas para a língua portuguesa

- Subteste 1: Escrita

Você necessita de óculos para leitura? Se necessitar, por favor, coloque-os. Com esta caneta preta, você deverá copiar a frase escrita neste cartão (por exemplo, AS BALEIAS MORAM NO MAR AZUL), com sua mão afetada pelo derrame, após eu falar “Preparar apontar já”, o mais rápido e mais legível que puder. Você entendeu a tarefa? Preparar, apontar, já!

- Subteste 2: Virar cartões

Você deverá virar estes cartões, um de cada vez, começando com o cartão da direita, se a mão afetada for a direita ou começando com o cartão da esquerda, se for a mão esquerda.

Após eu falar “Preparar apontar já”, vire o mais rápido que puder e sem errar. Todos os cartões deverão ser virados da mesma maneira, sem mudar a direção do movimento, ou seja, todos têm que ser virados do mesmo modo. Não é necessário que estejam organizados quando você terminar a tarefa. Você entendeu a tarefa? Preparar, apontar, já!

- Subteste 3: Pegar objetos pequenos

Você deverá colocar esses objetos, um de cada vez, dentro da lata. Se a mão acometida for a direita, os objetos estarão dispostos da seguinte maneira: da esquerda para direita, estarão os 2 clips, as duas tampas e as duas moedas. Desse modo, você começará pegando primeiro o clip da esquerda e assim por diante. Se for a mão esquerda, a disposição dos objetos será da seguinte maneira: da direita para a esquerda estarão os dois clips, as duas tampinhas e as duas moedas, e você deverá pegar primeiro o clip da direita e assim por diante.

Após eu falar “Preparar apontar já”, pegue um objeto de cada vez e o coloque dentro da lata, o mais rápido que puder e sem errar. Todos os objetos deverão ser pegos da mesma maneira, sem mudar a direção do movimento, ou seja, todos tem que ser colocados do mesmo modo. Você entendeu a tarefa? Preparar, apontar, já!

- Subteste 4: Simular alimentação

Com uma colher você colocará um feijão de cada vez dentro da lata. Se a mão acometida for à direita, os feijões estarão posicionados à direita da tábua e você começara pegando o primeiro feijão da direita. Se for a mão esquerda, os feijões estarão à esquerda da tábua, e você começa pegando o primeiro feijão da esquerda. Após eu falar “Preparar apontar já”, pegue o feijão e o coloque dentro da lata o mais rápido que puder e sem errar. Você entendeu a tarefa?

Preparar, apontar, já!

- Subteste 5: Empilhar damas

Você deverá empilhar as fichas no centro da tábua, pegando uma de cada vez, após eu falar “Preparar, apontar, já”, o mais rápido que puder e sem errar. Você pode começar a tarefa com qualquer ficha. Você entendeu a tarefa? Preparar, apontar, já!

- Subteste 6: Latas leves

Você deverá colocar uma lata de cada vez sobre a tábua. Se sua mão acometida for a direita, comece pegando a primeira lata da direita. Se for a mão esquerda, comece pegando a primeira lata da esquerda. Faça o mais rápido que puder e sem errar, após eu falar “Preparar, apontar, já”. Você entendeu a tarefa? Preparar, apontar, já!

- Subteste7: Latas pesadas

Você deverá colocar uma lata de cada vez sobre a tábua. Se sua mão acometida for a direita, comece pegando a primeira lata da direita. Se for a mão esquerda, comece pegando a primeira lata da esquerda. Faça o mais rápido que puder e sem errar, após eu falar “Preparar, apontar, já”. Você entendeu a tarefa? Preparar, apontar, já!

Anexo 4 – Teste Performance of Upper Limb

Performance of the Upper Limb Module for DMD 1.2 (PUL for DMD)								
Name or ID:			Date of birth:					
Date of assessment:			Spinal surgery: Y N (circle)					
Date:			Assessor / signature:					
Dominant arm:			Assessor / signature:					
Elbow contractures: Right:			Left:					
Ambulant / non-ambulant (circle)			Steroids / no steroids (circle)					
Entry item – start with Item A to identify starting point for subsequent tests. Circle score for each item.								
Item	Description	0	1	2	3	4	5	6
A.	Entry item	No useful function of hands.	Can use hands to hold pen or pick up a coin or drive a powered chair	Can raise 1 or 2 hands to mouth but cannot raise a cup with a 200g weight in it to mouth	Can raise standardized plastic cup with 200g weight in it to mouth using both hands if necessary.	Can raise both arms (to shoulder height with or without compensation .i.e. elbow bent or in extension	Can raise both arms simultaneously above head only by flexing the elbow (shortening circumference of the movement /using accessory muscles)	Can abduct both arms simultaneously elbows in extension in a full circle until they touch above the head.
If able to score 4 or 5 or 6 on item A , start with item B.								
High level shoulder Dimension								

Item	Description	0	1	2	3	4	5	6
B. Left/Rig ht	Shoulder abduction to shoulder height Elbow to shoulder level	Unable	Able no weights	200g	500g	1000g	Only tick / circle box if achieves B, C, D, E without compensation	
C. Left/Rig ht	Shoulder abduction above shoulder height Elbow to eye level	Unable	Able no weights	200g	500g	1000g		
D. Left/Rig ht	Shoulder flexion to shoulder height Elbow to shoulder level	Unable	Able no weights	200g	500g	1000g		
E. Left/Rig ht	Shoulder flexion above shoulder height Elbow to eye level	Unable	Able no weights	200g	500g	1000g		
Comments								

Performance of the Upper Limb Module for DMD 1.2 (PUL for DMD)								
Mid level elbow Dimension								
Do these tests on all individuals								
Item	Descripti	0	1	2	3	4	5	6

	on							
F. Left/ Right Both	Hand(s) to mouth	Unable	Able to bring 50g in cup to mouth using 2 hands	Able to bring 200g to mouth either with 2 hands or one hand with elbow support	Able to bring 200g in cup to mouth with one hand no elbow support			
G.	Hand(s) to table from lap	Unable	Gets both hands onto table but incompletely (just fingers or just one hand)	Two hands completely on table but not at same time	Two hands completely and simultaneously on table			
H. Left/ Right Both	Move weight on table	Unable	Can slide 100g weight from outer to centre circle without compensation	Can lift 100g weight from outer to centre circle without compensation	Can lift 200g weight from outer to centre circle without compensation	Can lift 500g weight from outer to centre circle without compensation	Can lift 1kg weight from outer to centre circle without compensation	
I. Left/ Right Both	Lifting light cans	Lift 0	Lift 1 (outer)	Lift 2	Lift 3 (centre)	Lift 4	Lift 5 (furthest away from preferred)	Time to lift 5 cans = --'-- min
J. Left/ Right Both	Lifting heavy cans	Lift 0	Lift 1 (outer)	Lift 2	Lift 3 (centre)	Lift 4	Lift 5 (furthest away from preferred)	Time to lift 5 cans = --'-- min

K.	Stacking light cans	Unable to stack 2 nd can	Stack 2 nd can	Stack 3 rd can	Stack 4 th can	Stack 5 th can	Time to stack all 5 cans =	— . — —
Left/ Right Both								
L.	Stacking heavy cans	Unable to stack 2 nd can	Stack 2 nd can	Stack 3 rd can	Stack 4 th can	Stack 5 th can	Time to stack all 5 cans =	— . — — min
Left/ Right Both								
M.	Remove lid from container	Unable to open.	Opens completely					
N.	Tearing paper	Cannot hold paper or tear it	Can hold piece of unfolded paper but cannot tear it	Tears the unfolded sheet of paper	Tears the sheet of paper folded in 2, beginning from the fold edge	Tears the sheet of paper folded in 4, beginning from the fold edge		
Performance of the Upper Limb Module for DMD 1.2 (PUL for DMD)								
Distal wrist and hand Dimension Do these tests on all individuals								
		0	1	2	3	4		
O.	Tracing path	With pencil in hand unable to hold it or make a mark	Able to hold pencil and can make a mark on paper	Able to follow the path for at least 5cm but not complete the path	Able to complete the path but needs to stop or raises pencil from paper	Able to pick up pencil and able to complete the path without stops or raising hand from paper		
Left/ Right								
P.	Push on the light	Unable to turn the light on with two hands	Able to turn the light on momentarily with two	Able to turn the light on momentarily with one	Able to turn the light on permanently with one hand			

			hands	hand			
Q. Left / Right	Turning light	Cannot pick up the light	Picks up the light but cannot turn the hand over	Picks up the light, and turns the hand over incompletely	Picks up the light and turns it over completely using compensatory movements	Picks up the light, and turns the hand over completely with no compensatory movements	
R. Left / Right	Picking up coins	Cannot pick up one coin	Can pick up one coin	Can pick up and hold three coins in one hand	Can pick up and hold six coins in one hand		
S. Left / Right	Placing finger on number diagram	Cannot raise the finger or slide it on the diagram	Cannot raise the finger to place it on a drawing but can slide it between at least two squares	Raises the finger and places it imprecisely on the numbers as shown	Raises finger and places it successively on the numbers of the diagram without touching the lines		
T. Left / Right	Lifting with finger pinch grip	Unable to achieve finger pinch grip 5 g 10 g	Able to achieve finger pinch grip but can't lift weight 5 g 10 g	Able to finger pinch and lift weight 5 g 10 g	Score for 5 g and/or 10 g weight Document variances in grip used		
U. Left / Right	Lifting with 3 point grip	Unable to achieve 3 point grip 5 g 10 g	Able to achieve 3 point grip but can't lift weight 5 g 10 g	Able to 3 point grip and lift weight 5 g 10 g	Score for 5 g and/or 10 g weight Document variances in grip used		
V. Left / Right	Lifting with Thumb (key) grip	Unable to achieve thumb grip or bend end	Unable to achieve thumb grip but can	Able to achieve thumb grip but can't lift	Able to grip and lift weight	Score for 5 g and/or 10 g weight Document	

		of thumb	move end of thumb	weight	5 g	10 g	variances in grip used
		5 g 10 g	5 g 10 g	5 g 10 g			

Additional Material

Item 0: Tracing a path

Item S: Placing finger on number diagram

Instruction: Starting on the yellow number 1 point to the numbers 1 to 10 in turn following the arrow

Anexo 5 – Resumo apresentado no 4º Congresso Brasileiro de Fisioterapia Neurofuncional

**RELATIONSHIP BETWEEN JEBSEN-TAYLOR TEST AND
PERFORMANCE OF UPPER LIMB IN DUCHENNE MUSCULAR
DYSTROPHY**

**Relação entre o teste Jebsen-Taylor e o desempenho de membros
superiores na distrofia muscular de Duchenne**

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Introdução e objetivos: O teste PUL avalia a função do ombro, cotovelo e mão na DMD. Combinado com o TESTE DE JEBSEN-TAYLOR, que foi aplicado anteriormente na população e evidenciou uma forma precisa de avaliar a função cronometrada, pode representar um protocolo específico de avaliação do membro superior. O objetivo do estudo foi investigar a relação entre estes instrumentos em pacientes com DMD. **Métodos:** 16 pacientes com DMD e 3 com Becker (18.3 ± 5.0) permaneceram sentados e foram submetidos à aplicação dos domínios de ombro, cotovelo e punho da PUL, pontuados de 0

– 4 ou 0 – 6, com pontuação máxima de 74, e também dos subtestes do TESTE DE JEBSEN-TAYLOR, obtendo-se o tempo cronometrado para realização dos mesmos para os dois membros. O Subteste 7 – pegar objetos largos e pesados – foi impossibilitado de ser executado pelos pacientes. Para análise de relação entre os testes, o Teste de Spearman foi aplicado e seus resultados interpretados como de correlação forte ($r \geq 0,70$), moderada ($0,40 \leq r < 0,70$) ou fraca ($r \leq 0,40$). **Resultado:** Foi encontrada correlação forte entre os escores totais do PUL e do TESTE DE JEBSEN-TAYLOR ($r = 0,761$). Os resultados também mostraram correlação forte entre o item “lifting light cans” do PUL e os subtestes 3 ($r = 0,722$) e 6 ($r = 0,742$) do TESTE DE JEBSEN-TAYLOR, bem como entre o item “lifting heavy cans” do PUL e os subtestes 3 ($r = 0,751$), 4 ($r = 0,759$) e 6 ($r = 0,734$) do TESTE DE JEBSEN-TAYLOR. Correlação moderada foi encontrada entre os itens “lifting light cans” e “lifting heavy cans” do PUL e os outros subtestes do TESTE DE JEBSEN-TAYLOR. **Discussão e conclusão:** A correlação forte encontrada, apesar da diferente mensuração, pode ser explicada pela similaridade de itens como “lifting light cans” do PUL e o subteste 6 do TESTE DE JEBSEN-TAYLOR, além da semelhante ativação muscular para desempenho dos itens de avaliação. Pode-se sugerir que os testes mensuram características similares da função de membro superior. O uso combinado dos mesmos representa uma mensuração precisa de monitoramento da progressão das DM.

Palavras-chave: Distrofias Musculares; Distrofia Muscular de Duchenne; extremidade superior; avaliação da deficiência.

Anexo 6 – Resumo apresentado no XXVII Congresso Brasileiro de Neurologia

**PATIENTS WITH DUCHENNE MUSCULAR DYSTROPHY ARE NOT
MORE ASYMMETRICAL THAN HEALTHY CONTROLS IN FUNCTIONAL
UPPER LIMB TASKS**

***Pacientes com Distrofia Muscular de Duchenne não são mais
assimétricos que controles saudáveis sm tarefas funcionais de membros
superiores***

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INTRODUCTION: Due to the progressive nature of DMD, upper extremity weakness and limitations impair the ability of performing daily activities. Patients with DMD seem to be more asymmetrical than healthy controls. The dexterity of the non-dominant limb seems to be relatively poorer in DMD patients, due to

disuse. However, this hypothesis has not been investigated in literature before.

OBJECTIVE: This study aimed (1) to compare upper limbs functional asymmetry of patients with DMD and normative data from healthy subjects; (2) to investigate possible asymmetries and relationships between dominant and non-dominant upper limbs performance and (3) between timed performance of upper limbs and other functional tests in patients with DMD. **METHOD:** Twenty patients with DMD were evaluated with JTT, timed performance, Dimension 3 of MFM (functional performance), Mini-Mental State Examination, Vignos Scale and Brooke Scale on a single session. **RESULTS:** We found similar asymmetries between the upper limbs of DMD patients and healthy controls ($p>0.050$) when dominant and non-dominant were compared, for both DMD and controls). We found strong relationships between dominant and non-dominant limbs performances ($r>0.70$ and $p<0.050$ for all tasks of JTT). Moderate to strong correlations were found between the timed tasks of JTT and the other clinical tests scores ($r>0.50$ and $p<0.050$ for all relationships). **CONCLUSION:** The timed performances of dominant and non-dominant upper limbs were highly correlated in DMD patients and healthy controls. This information may reduce the assessment time, prevent fatigue and provide more accurate clinical reasoning involving upper limbs in DMD treatment. The performance on tests with timed tasks is correlated to the performance on other gold-standard clinical tests of the literature and should be used as a complementary tool in DMD assessment.

Anexo 7 – Resumo apresentado no 23rd International Annual of the World Muscle Society

Bringing the spoon to the mouth or the mouth to the spoon? The analysis of compensatory movements of simulated feeding in Duchenne muscular dystrophy: a case-control study

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The difficulty of bringing the spoon to the mouth is frequently reported by people with Duchenne muscular dystrophy. Simulated feeding assessment can reveal several compensatory movements. Such movements are employed to maintain the functional performance when muscular weakness progresses. This study aimed to describe and compare the performance of men with Duchenne muscular dystrophy and age-matched controls (participants aged from 11 to 29 years and volunteers with Duchenne muscular dystrophy were classified as Vignos 1 to 8). Simulated feeding was evaluated by asking volunteers to bringing the spoon to the mouth. The compensatory movements performed

during the task were observed and described. Twenty-six people with Duchenne muscular dystrophy and twenty-two healthy controls were filmed while performing the task. Six kinematic variables are used to evaluate the compensatory movements: initial and final angle of head flexion; initial and final angle of elbow flexion; peak velocity and total time. Kinovea software (version 8.25) and Statistica software (version 13.0) were used for movement and data analyses. The kinematic analysis showed that people with Duchenne muscular dystrophy differed from controls in several variables. Analysis of variance evidenced that people with Duchenne muscular dystrophy showed increased initial and final angles of elbow flexion, increased final angle of head flexion and increased total timed performance ($p < 0.05$) in all comparisons). In conclusion, the assessment of bringing the spoon to the mouth (simulated feeding) can be used in clinical practice to describe compensatory movements in initial and/or late stages of Duchenne muscular dystrophy.