ORIGINAL ARTICLE

Evaluation of grip strength and range of motion of the upper limbs in patients with mucopolysaccharidosis VI

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ABSTRACT

Objective: The present study aims to evaluate the grip strength and range of motion of the upper limbs of patients with Mucopolysaccharidosis VI in order to observe how these factors can affect and correlate with the activities of daily living. **Methods:** The sample consisted of 13 patients: 8 males and 5 females, with a mean age of 17.76 years, mean weight of 31.30Kg, and a mean height of 1.17m, who agreed to participate and who met the inclusion criteria. The study was conducted in the state of Pernambuco at the Inborn Errors of Metabolism Treatment Center (*Centro de Tratamento de Erros Inatos do Metabolismo*), located at the Integrative Medicine Institute (*Instituto de Medicina Integral*) Prof. Fernando Figueira (IMIP). Range of motion (ROM) measurements of their upper limbs and manual grip strength were collected, and the subjects answered a structured questionnaire. **Results:** In this study the flexion of the shoulder joint that had the greater impairment mostly did not follow this pattern, since the average ROM for the left arm was 90.38 and 93.38 for the right. The ROM found to be the farthest below the predicted average in the study was for wrist extension in both the left and right limbs. In grip strength assessment, only one individual measured above the predicted average, 9 (69.21%) showed a degree of strength between 0 and 2 pounds (lb) in the right hand and 8 (61.52%) in the left. **Conclusion:** This study hopes to serve as a means of monitoring the evolution of MPS VI , which can support new studies, evaluation protocols, and motor rehabilitation.

Keywords: Mucopolysaccharidosis VI, Upper Extremity, Hand Strength, Physical Therapy Modalities

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INTRODUCTION

The Mucopolysaccharidoses (MPS) form a heterogeneous group of rare and hereditary metabolic diseases caused by the deficiency of enzymes needed to break down glycosaminoglycans (GAG).[1] The MPS are divided into seven types, where each subtype presents specific characteristics and dysfunctions.[2] Although individually rare, they are relatively frequent when seen together, showing a global incidence estimated at 1:22,000.[3]

In the MPS type VI (Maroteaux Lamy Syndrome), the deficient enzyme is the N-acetylgalactosamine-4-sulfatase or arylsufatase B, which is considered as one of the rarest types of MPS[4] in the world and has an incidence of 0.23 for each 100,000 live births.[5] However, in Brazil, the situation is the opposite, with the MPV type VI being one of the most frequent types diagnosed.[4]

Apparently, children with MPS are normal at birth, which very much hinders its diagnosis and early treatment.[6] For most individuals with MPS type VI, the first signs of the disease are presented in childhood,[4] however the diagnosis is, many times, delayed due to the absence of cognitive impairment.[7] MPS VI presents dysfunctions that affect many systems: body organs and joints, whose dysfunctions such as joint stiffness and osteoarticular manifestations can cause significant functional losses.[4,8]

Limitations to movements and flexional contractions of the joints affect especially the knees, hips, elbows, wrists, and fingers.[8,9,10] There is an inversely proportional relationship between age and the mobility of these joints—for the older the patient, the worst the mobility.[4] Thus, the evaluation of joint mobility can be considered a good marker of the evolution of MPS type VI.[4]

The main causes for the dysfunctions that lead to impairment in activities of daily living are changes in the connective tissue that leads to a loss of joint mobility, a reduction in the range of motion (ROM) of many joints, and a loss of muscle strength, especially in the flexion and extension of the hands and in the pronation and supination of the forearm.[11,12]

Functional losses in the thumbs, wrists, and fingers that lead to claw hands are associated with carpal tunnel syndrome and to the accumulation of GAGs.[11,12] All the changes found in MPS type VI contribute to a significant disability to perform simple acts.[6,8]

OBJECTIVE

The present study sought to evaluate the grip strength and range of motion of the shoulder, elbow, wrist, and hand joints—correlating them with the activities of daily living.

METHOD

The sample was made up of 13 patients of both genders, aged between 7 and 39 years with Mucopolysaccharidosis type VI, registered at the Inborn Errors of Metabolism Treatment Center at the Integrative Medicine Institute Prof. Fernando Figueira (*Centro de Tratamento de Erros Inatos do Metabolismo do Instituto de Medicina Integral Prof. Fernando Figueira – CETREIM-IMIP*) who were treated with Enzyme Replacement Therapy (ERT).

The study included all the patients with confirmed diagnoses of MPS type VI, with preserved cognitive function, of both genders, older than seven years of age, and it excluded patients with traumatic injury to the upper limb and those who refused to perform or complete any phase of the data collection.

The present study respected the principles of ethics in research on humans including autonomy, non-maleficence, justice, and beneficence, in accordance with Resolution 466/12 from the National Health Council. All the patients were informed of the objectives and methodology of the study and were then invited to participate. The study was begun after approval by the Committee for Ethics in Human Research from the *Hospital Memorial Guararapes* (Guarapes Memorial Hospital)/PE under CAAE No. 35299214.3.0000.5199 and carried out between October and November of 2014 in a room of the CETREIM-IMIP after the adult patients signed the Free and Informed Consent form and the legal guardians of the patients aged between 7 and 17 years signed the Consent Terms for their participation.

Data collection proceeded with questions regarding the identification and clinical data of the participants, followed by the participants answering a structured questionnaire prepared by the researcher. After that, the range of motion of the upper limbs was measured and the handgrip strength test was applied.

After agreeing to participate in the present study, the participants were taken to a room at the CETREIM-IMIP, where they signed the Free and Informed Consent form or Consent Terms, according to their age, and had their ROM and hand grip strength evaluated in the seated position (90º of hip and knee), with their feet supported and by only one researcher.

Done in phases, the procedure for the identification questionnaire was composed of questions asked directly to the participant in which he or she would answers questions such as name, gender, and age, etc., and sociodemographic questions such as address, schooling, and profession. After that, the individual was questioned about the presence of pain in their upper limbs (using a modified Borg scale), about the presence of joint stiffness (explained to the patient as a hard, difficult-to-move joint), and about their level of functional performance in activities of daily living (ADLs) such as brushing their teeth, combing their hair, and writing, etc.

Their joint mobility was evaluated actively and measured by a standardized technique through flexion, extension, and abduction of shoulders; flexion and extension of elbows; radioulnar pronation and supination of the elbow, and finally flexion and extension of the wrist using a goniometer (Carci®, Brazil), with the unit of measure in degrees (º).

To finish, the grip strength of both hands was measured with a manual hydraulic dynamometer (Baseline®, U.S.A), whereby the individuals remained seated, adjusted to their proper height, with their feet on the ground with knees and hips flexed at 90º. The shoulder remained adducted and the elbow was positioned at 90º flexion with the forearm in neutral position. The standard adjustable strap was placed in the first position for participants aged between 7 and 19 years and in the second position for participants older than 20. An interval of one minute between the three measurements was observed and the final result was considered to be the average of the values obtained, using pounds for the unit of measure for children[13] and adults.[14]

Statistical data was obtained using the SPSS 13.0 and Excel 2007 softwares, which is presented in the form of tables and/or graphics with their respective absolute and relative frequencies. The numerical variations are represented by the central tendency and dispersion measurements.

RESULTS

The study included 13 patients receiving ERT for more than one year, with eight males (61.5%) and five females (38.5%), with mean age at the time of evaluation of 17.76 years

and mean weight and height of 31.30kg and 1.17cm, respectively. As for hand dominance, 100% of the participants in the sample presented the right hand as the dominant one. At the time of the collection, 10 individuals (76.9%) stated that they attended a school or college.

Carpal tunnel syndrome was confirmed in only two (15.4%) of the 13 patients. Regarding associated therapies, five patients (38.5%) received physiotherapy once a week for 50 minutes and no patient reported receiving Occupational Therapy or practicing any structured physical activity.

In this sample, no patient reported stiffness in elbow joints. However, in the remaining joints of the upper limb, three patients (23.1%) reported stiffness in shoulder joints, two (15.4%) in wrists, and two (15.4%) in the metacarpophalangel joints (MCPs) and in the distal and proximal interphalangeal joints (DIPs and PIPs) of the hand.

The presence of pain in upper limbs was reported by 10 patients (76.9%). The location of pain, the number of subjects, and the Borg Mean are shown in Table 1.

When questioned about the use of medication for pain in upper limbs, seven patients (53.8%) reported using analgesics.

The analyses of range of motion of the shoulder and wrist joints (flexion and extension) are shown in Table 2 with their medians and amplitudes, respectively. The data obtained from analyzing the means and amplitude, respectively, of the left forearm were: pronation 59.85: 24-90, supination 34.77: 6-52, and in the right elbow: pronation 57.38: 30-90 and supination 35.69: 8-60.

The following data were obtained for the left elbow joint: flexion 68.62: 30-96, and for the right 73.46: 35-114, while in the left wrist joint, radial deviation was 18: 6-30, ulnar deviation was 13.69: 0-32, and in the right limb, radial deviation 16.92: 6-30 and ulnar deviation 13.23: 4-30. No relationship was found between the ranges of motion measured and the time receiving ERT.

In the evaluation in pounds made with the dynamometer, nine patients (69.21%) presented a degree of strength between 0 and 2 for the right hand and eight patients (61.52%) presented a degree of strength between 0 and 2 for the left hand. The other dynamometer values obtained and predicted are shown in Table 3.

The difficulties most present in the patients' activities of daily living, according to the structured questionnaire analysis, are listed in Figure 1. Listing the least mentioned in ascending order: holding a tooth brush 1 (7.7%), brushing teeth 2 (15.4%), applying the tooth paste to the brush 3 (23.1%), holding a glass and writing 4 (30.8%), cleaning oneself and opening any rounded handle or knob 5 (38.5%).

Table 1. Pain characteristics in 13 patients with Mucopolysaccharidosis type VI registered at the Inborn Errors of Metabolism Treatment Center in Pernambuco, 2014

Variables	N	% Borg Mean
Shoulder joint pain Yes	3	23.1 5.3
Elbow joint pain Yes	2	15.4 6
Wrist joint pain Yes	2	15.4 6
Pain in MCP, DIP, and PIP joints Yes	10	76.9 5.2

N: Number of patients

Table 2. Characteristics in 13 patients with Mucopolysaccharidosis type VI registered at the Inborn Errors of Metabolism Treatment Center in Pernambuco, 2014

Range of Motion [a](°)	(Med, amplitude)
Shoulder flexion L (0-180°)	90.38: 46-162
Shoulder flexion R (0-180°)	93.38: 30-152
Shoulder extension L (0-60°)	47.07: 30-60
Shoulder extension R (0-60°)	41.30: 16-60
Shoulder abduction L (0-180°)	86.15: 34-140
Shoulder abduction R (0-180°)	85.08: 38-140
Wrist flexion L (0-90°)	49.31: 16-90
Wrist flexion R (0-90°)	37.77: 16-60
Wrist extension L (0-90°)	18.46: 0-46
Wrist extension L (0-90°)	17.54: 0-48

L: Left limb; R: Right limb. Values expressed in Mean; (°): Degrees [a] Values obtained from Palmer and Epler.

DISCUSSION

In the present study, one can see that the individuals are above average in height for those with a fast evolution of the disease, since the first signs of osteoarticular changes with MPS type VI are short stature (where the individuals reach a height of 95-100cm in a fast evolution of the disease and up to 140-150cm in a slow evolution) and joint stiffness (especially in knees, hips, and elbows).[4]

Carpal tunnel syndrome has been reported in the present study by only two patients who had their diagnosis confirmed by medical exam, as well as wrist stiffness, also found in only two patients. The articular function of these individuals is considered abnormal due to the thickening and fibrosis of the articular capsule, generating limitations in large joints as well as in the small joints of the fingers, which gives the hand the appearance of a claw.[15] Carpal tunnel syndrome is a common occurrence in people with MPS type VI.[15]

The progressive pain present in the joints and the absence of joint mobility represent an important source of morbidity in those patients.[7] The present study confirmed the strong presence of pain in the shoulder, elbow, and wrist joints, with the most painful joints reported being the MCPs, DIPs, and the PIPs. This runs contrary to the study by Aslam et al. on MPS type VI, in which most of the individuals studied 7 (10) reported not feeling pain at any time.[16]

Of the changes in ROM, shoulder flexion[6] is the one most impaired, having no correlation with age and being a clinical sign of a possible MPS type VI diagnosis.[4] The present study observed that in shoulder flexion, individuals obtained the mean of what was predicted for the joint, however, the same patients presented range limitations in all the joints, especially seen in elbow flexion, in which the means were below what was predicted.

In the study by Cardoso-Santos et al.,[6] the analysis of range of motion showed greater impairment in decreasing order of severity for shoulder flexion, elbow flexion, elbow extension, and shoulder extension, which agreed with the current results.

Table 3. Measurements of grip strength of 13 patients with MPS VI

Patient	Age	Strenght (lb) RH	Predicted Strenght (lb) RH	Strenght (lb) Interval RH	Strenght (lb) LH	Predicted Strenght (lb) LH	Strenght (lb) Interval LH
1	37	5	26,1	21-32	6	25,6	18-32
2	21	2	17,6	14-23	3	16,2	13-23
3	19	2	20,2	10-26	2	19	14-25
4	15	2	19,2	11-28	3	18,8	10-33
5	12	2	15,4	11-23	1	14,2	10-20
6	9	1	10,7	8-17	2	10,3	6-20
7	12	2	15,5	8-26	2	15,1	8-23
8	32	36	26,4	20-36	36	26,2	17-36
9	7	1	10	5-13	2	9,2	5-13
10	8	1	11,6	7-17	0	11,2	6-16
11	11	0	13,9	7-21	1	13,2	8-23
12	39	13	26,1	21-32	17	25,6	18-32
13	9	1	10,7	8-17	1	10,3	6-20

RH: Right Hand; LH: Left Hand

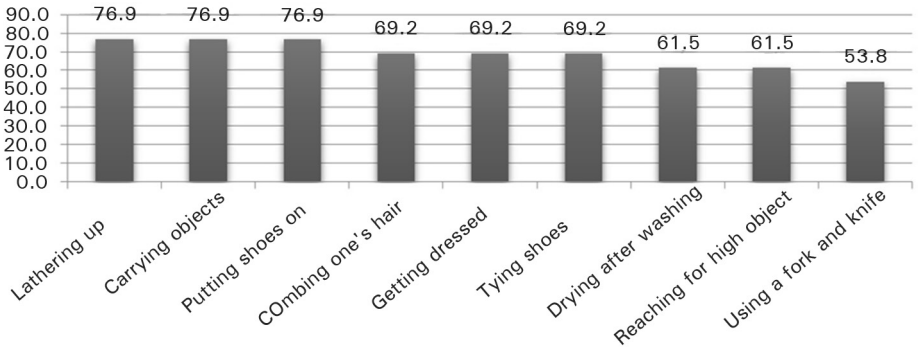

Figure 1. Main ADL difficulties listed by the 13 patients with MPS type VI

For Aslam et al.[16] the mean radial deviation for active ROM was 6º and the mean ulnar deviation for active ROM was 30º, which reinforce the presence of hyper joint mobility in patients with MPS type VI, contrary to the present study, in which patients presented a general mean radial deviation for ROM of 17.46º and a mean ulnar deviation for ROM of 13.46º, probably due to the joint stiffness presented by those patients.

For Muenzer,[7] skeletal changes result in a serious loss of joint range of motion and restricted mobility commonly involving of wrists and hands, leading to reduction in the wrist ROM, stiffness of PIP joints, and claw-like fingers in individuals with MPS types I, II, and VII; all those functional losses occur due to the accumulation of GAGs.[17] The same could be observed in the present study in which the wrist ROM was the most impaired when compared to the means of the other joints evaluated. The ROM evaluations helped in the identification of difficulties in mobility, however, this technique alone cannot measure one's performance in the ADLs.[17]

For Cardoso-Santos et al.[6] the fact that grip strength had been 0 in 23 out of 26 patients reflected the great impairment to the flexion of fingers associated with MPS type VI. In the present study, such clinical data can only aggregate, since 12 out of 13 patients presented a mean grip strength much lower than that predicted, it is important to highlight that the clinical signs observed in the study when acting together lead to difficulty in performing the ADLs.

The limitation in the performance of the ADLs is clear in the study, since the 13 participants listed on average 6.5 activities performed with difficulty, out of the 16 proposed in the questionnaire. In the study by Aslam et al.,[16] among the activities listed, only carrying an object and cleaning oneself were relevant, with means of 4 and 4.5, respectively, for individuals between 5 and 9 years old, and carrying a heavy object with a mean of 4.75 for those older than 10.

Physical exercise and rehabilitation practice are two components necessary for better quality of life and of the ADLs. This study indicates the need for a rehabilitation program during the ERT, as well as the intervention of a physiotherapist along with an interdisciplinary team involved in the care of these patients.[18] Studies that deal with ranges of motion and grip strength in patients with Mucopolysaccharidosis and Mucopolysaccharidosis type VI are scarce and use ERT as a treatment outcome variable.[6]

CONCLUSION

This study hopes to serve as a form of monitoring the evolution the MPS type VI, encouraging the performance of Physiotherapy in promoting a better quality of life and attenuating the clinical signs and symptoms of the disease. May this study enable new studies and protocols for evaluation and motor rehabilitation in this population, providing information for the improvement of clinical care for these patients, drawing the attention of the scientific community to the importance of this issue.

REFERENCES

1. Dieter T, Matte U, Barbosa F, Schwartz I, Giugliani R. Introdução às mucopolissacaridosis. Porto Alegre: HCPA; 2002.
2. Lin SP, Shih SC, Chuang CK, Lee KS, Chen MR, Niu DM, et al. Characterization of pulmonary function impairments in patients with mucopolysaccharidoses- changes with age and treatment. Pediatr Pulmonol. 2014;49(3):277-84. DOI: http://dx.doi.org/10.1002/ppul.22774
3. Giugliani R. Mucopolysacccharidoses: From understanding to treatment, a century of discoveries. Genet Mol Biol. 2012;35(4 (suppl)):924-31. DOI: http://dx.doi.org/10.1590/S1415-47572012000600006
4. Mizuno CA, Figueiredo JB, Teza ITV, Taira LGN, Silva TA, Paixão DL, et al. Aspectos clínicos da mucopolissacaridose tipo VI. Rev Soc Bras Clín Méd. 2010;8(4): 356-61.
5. Giugliani R, Federhen A, Rojas MV, Vieira T, Artigalás O, Pinto LL, et al. Mucopolysaccharidosis I, II, and VI: Brief review and guidelines for treatment. Genet Mol Biol. 2010;33(4):589-604. DOI: http://dx.doi.org/10.1590/S1415-47572010005000093
6. Cardoso-Santos A, Azevedo AC, Fagondes S, Burin MG, Giugliani R, Schwartz IV. Mucopolysaccharidosis type VI (Maroteaux-Lamy syndrome): assessment of joint mobility and grip and pinch strength. J Pediatr (Rio J). 2008;84(2):130-5. DOI: http://dx.doi.org/10.2223/JPED.1743

7. Muenzer J. Overview of the mucopolysaccharidoses. Rheumatology (Oxford). 2011;50 Suppl 5:v4-12. DOI: http://dx.doi.org/10.1093/rheumatology/ker394
8. Matos MA, Barreto R, Penha CE, Soares C, Costa AA. Amplitude de movimentos em pacientes com mucopolissacaridose (mps-i, mps-ii e mps-vi), após um ano de terapia de reposição enzimática. Rev baiana saúde pública. 2010;34(Supl 1):60-1.
9. Vieira TA. História natural das mucopolissacaridoses: uma investigação da trajetória dos pacientes desde o nascimento até o diagnóstico [dissertação]. Porto Alegre: Universidade Federal do Rio Grande do Sul; 2007.
10. Giugliani R, Federhen A, Muñoz Rojas MV, Vieira TA, Artigalás O, Pinto LL, et al. Enzyme replacement therapy for mucopolysaccharidoses I, II and VI: recommendations from a group of Brazilian F experts. Rev Assoc Med Bras. 2010;56(3):271-7. DOI: http://dx.doi.org/10.1590/S0104-42302010000300009
11. Rocha JSM, Bonorandi AD, Oliveira LS, Silva MNS, Silva VF. Avaliação do desempenho motor em crianças com mucopolissacaridose II. Cad Ter Ocup UFSCar. 2012;20(3):403-12. DOI: http://dx.doi.org/10.4322/cto.2012.040
12. Morini SR. Caracterização do sistema músculo-esquelético em indivíduos com mucopolissacaridoses tipo II: alguns aspectos cinéticos e consequências funcionais [dissertação]. Campinas: Universidade Estadual de Campinas; 2007.
13. Mathiowetz V, Wiemer DM, Federman SM. Grip and pinch strength: norms for 6- to 19-year-olds. Am J Occup Ther. 1986 ;40(10):705-11. DOI: http://dx.doi.org/10.5014/ajot.40.10.705
14. Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S. Grip and pinch strength: normative data for adults. Arch Phys Med Rehabil. 1985;66(2):69-74.
15. Pereira JO, Gabriela M, Moreira DA, Palazzo VC. Mucopolissacaridose tipo VI: evolução natural, importância diagnóstica e terapêutica. Rev Neurocienc. 2011;19(2):329-38.
16. Aslam R, van Bommel AC, Hendriksz CJ, Jester A. Subjective and Objective Assessment of Hand Function in Mucopolysaccharidosis IVa Patients. JIMD Rep. 2013;9:59-65.
17. Guarany NR, Schwartz IV, Guarany FC, Giugliani R. Functional capacity evaluation of patients with mucopolysaccharidosis. J Pediatr Rehabil Med. 2012;5(1):37-46.
18. Tylki-Szymanska A, Marucha J, Jurecka A, Syczewska M, Czartoryska B. Efficacy of recombinant human alpha-L-iduronidase (laronidase) on restricted range of motion of upper extremities in mucopolysaccharidosis type I patients. J Inherit Metab Dis. 2010;33(2):151-7. DOI: http://dx.doi.org/10.1007/s10545-010-9059-9