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EDITORIAL

Using 3D printing to improve accessibility of the Nine-Hole test in Mexico

Uso de la impresión 3D para mejorar la accesibilidad de la prueba de Nueve Hoyos en México

Moisés M. Gallardo-Pérez[1] and Solón J. Garcés-Eisele[2,3]*

[1]Facultad de Medicina, Universidad del Valle de Puebla; [2]Facultad de Biotecnología, Universidad Popular Autónoma del Estado de Puebla; [3]Departamento de Biología Molecular, Laboratorios Ruiz SYNLAB. Puebla, Mexico

The Nine-Hole Peg Test (NHPT) is a test that is used to evaluate manual dexterity and fine motor skills. It was designed by Kellor et al. in 1971 and Mathiowetz et al. in 1985 published detailed instructions for the design and application of the test[1,2]. The main advantages of this test are that it is simple, easy to transport, easy to administer and requires a short time to administer. The NHPT is used to assess manual dexterity in patients with hand injury and in neurodegenerative diseases such as Parkinson's disease[3] or multiple sclerosis[4] in which the NHPT is part of the Multiple Sclerosis Functional Composite which is a standardized test used primarily in clinical studies and consists of three assessments: walk/leg function, arm and hand function, and cognitive function[5].

In our country, access to the NHPT is limited. It is difficult to find the test even in specialized stores. Facing this problem, we undertook the task of designing a 3D model of the NHPT with the use of SketchUp 2018 software that was printed on a Dremel 3D printer model 3D20 (Fig. 1). We can assume that this tool is valid for clinical evaluation as it complies with the measures of the original test design proposed by Mathiowetz et al.

We have performed preliminary measurements in 18 subjects, with a median age of 28 years (interquartile range = 24-66) and no history of neurological diseases, obtaining promising results. Intraclass correlation coefficient (ICC) from dominant hand (Jamar and 3D printed) was 0.769 (95% confidence interval: [CI] 0.388-0.913) and for non-dominant hand was 0.832 (95% CI: 0.543-0.937). ICC estimates and 95% CI were calculated using the Statistical Package for the Social Sciences (SPSS) version 25 (SPSS Inc., Chicago, IL) based on a mean-rating (k = 2),

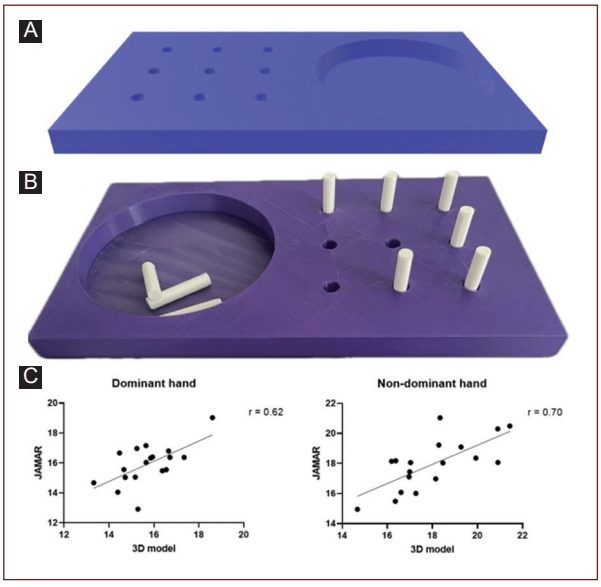

Figure 1. Nine-Hole Peg Test model. **A:** model created with SketchUp 2018. **B:** model printed with Dremel 3D20. **C:** analysis of the correlation between Jamar times and the 3D model.

***Correspondence:**
Moisés M. Gallardo-Pérez
E-mail: moymgp@gmail.com

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absolute-agreement, two-way mixed-effects model. As shown in figure 1, the correlation coefficient for the dominant hand was 0.62 (p = 0.006) while for the non-dominant hand, it was 0.70 (p = 0.001).

It is undeniable that parts printed on a 3D printer can become unspecific. Factors such as printing speed and the height of each layer can influence the final measurements of the model and in the case of the NHPT not present the exact measurements[6]. However, the use of free software such as Cura or commercial software such as Simplify, and the standardization of printing profiles, can help to diminish these effects and help to maintain the proper configuration of the model.

With the advance of technology, tools have been designed and evaluated that allow patients to be evaluated remotely or by virtual reality. However, it has been reported that in a virtual NHPT, patients take longer to perform the test compared to the traditional test[7], so, despite being a viable option, new standards would have to be adapted for the validation of these new tools.

The regular use of the test allows neurologists to perform a comprehensive evaluation of the patient with upper-limb alterations. Since, in our country, the accessibility to this test is limited, we believe that 3D printing can be the way to have valid and low-cost models. The average printing time for this model is in the range of 2.5-5 h, depending on the print settings and the cost of the material required to print this model (standard polylactic acid filament) would be in the range of 5-15 dollars. Several universities in our country have 3D printers and could help to replicate models or even propose new tests that could further improve the clinical neurological evaluation.

The STL files for printing this model will be shared upon request with the corresponding author.

References

1. Mathiowetz V, Weber K, Kashman N, Volland G. Adult norms for the nine hole peg test of finger dexterity. Occup Ther J Res. 1985;5:24-38.
2. Kellor M, Frost J, Silberberg N, Iversen I, Cummings R. Hand strength and dexterity. Am J Occup Ther. 1971;25:77-83.
3. Proud E, Morris ME, Bilney B, Miller KJ, Nijkrake MJ, Munneke M, et al. Hand dexterity assessment in Parkinson's disease: construct validity of the 9-Hole peg test for the more affected hand. Disabil Rehabil. 2021;43:3834-8.
4. Solaro C, Cattaneo D, Brichetto G, Castelli L, Tacchino A, Gervasoni E, et al. Clinical correlates of 9-hole peg test in a large population of people with multiple sclerosis. Mult Scler Relat Disord. 2019;30:1-8.
5. Solari A, Radice D, Manneschi L, Motti L, Montanari E. The multiple sclerosis functional composite: different practice effects in the three test components. J Neurol Sci. 2005;228:71-4.
6. Bakardzhiev V, Sabev S, Chukalov K, Kasabov P. Research into the accuracy of holes in 3D printing using Taguchi method. Vide Tehnol Res-Environ Technol Res. 2023;3:36-40.
7. Park W, Jamil MH, Wasti S, Eid M. Immersive virtual reality simulation of the Nine-Hole Peg Test for post-stroke patients. In: Stephanidis C, Antona M, Ntoa S, Salvendy G, editors. HCI International 2023 Posters. Cham: Springer Nature Switzerland; 2023. p. 125-9.