How to cite: *Ferreira DM, Carvalho LC, Kosour C, Santos ATS, Marin LF, Santos GX, et al. Inter-and intra-rater analysis of hemiparetic shoulder abduction using PhysioPlay™: software for measuring range of motion. Acta Fisiatr. 2019;26(3). Doi: https://doi.org/10.11606/issn.2317-0190.v26i3a166375*

OJS 166375 | Original Article

Inter-and intra-rater analysis of hemiparetic shoulder abduction using PhysioPlay™: software for measuring range of motion

Análise inter e intra-avaliador da abdução do ombro hemiparético pelo PhysioPlay™: software para medir a amplitude de movimento

Daiane Marques Ferreira[1], Leonardo César Carvalho[1], Carolina Kosour[1], Adriana Teresa Silva Santos[1], Lucas Fechio Marin[2], Gabriela Xavier Santos[1], Paulo Alexandre Bressan[2], Luciana Maria dos Reis[1]

1 Departamento de Fisioterapia, Universidade Federal de Alfenas – UNIFAL
2 Instituto de Ciências Exatas, Universidade Federal de Alfenas – UNIFAL

Correspondência
Luciana Maria dos Reis
reislucianamaria@gmail.com

Submetido: 28 Setembro 2019.
Aceito: 27 Fevereiro 2020.

ABSTRACT
Changes in balance are observed in some hemiparetics following a stroke, generating significant physical, social, and economic impacts; thus, an assessment was developed to facilitate treatment plans for patients. Goniometry is currently used as an evaluation tool for range of motion (ROM); however, the development of exergames has brought a new perspective to the assessment, which uses a dynamic mechanism and has little subjectivity. **Objective:** This study evaluates the inter-and intra-rater reliability of ROM measurement of the shoulder abduction in post-stroke patients using the exergame PhysioPlay™. **Method:** Thirteen volunteer chronic stroke survivors, aged 58.23 ± 9.96 years (men and women), participated in this study. Two physiotherapists evaluated the abduction of the shoulder using goniometry and the exergame PhysioPlay™. A retest was performed one week later. Clinical trial registry number – RBR-55smwr. **Results:** The results of the analyses using intraclass correlation coeficient (ICC) showed an excellent inter- and intra-rater reliability level ($r > 0.90$; $p < .05$). The Pearson correlation between the maximum measures obtained in the goniometry and the software PhysioPlay™ showed a high correlation ($r > 0.90$, $p = .001$). **Conclusion:** The Kinect associated with the exergame PhysioPlay™ presented excellent reliability in capturing the ROM measure compared to the conventional goniometry.

Keywords: Stroke, Rehabilitation, Physical Therapy Specialty, Arthrometry, Articular

RESUMO
Alterações no equilíbrio são observadas em hemiparéticos após um acidente vascular encefálico (AVE), gerando impactos físicos, sociais e econômicos significativos; assim, uma avaliação foi desenvolvida para facilitar os planos de tratamento para os pacientes. A

goniometria é atualmente usada como ferramenta de avaliação da amplitude de movimento (ADM); no entanto, o desenvolvimento de exergames trouxe uma nova perspectiva para a avaliação, que utiliza um mecanismo dinâmico e tem pouca subjetividade. **Objetivo:** Este estudo avaliou a confiabilidade inter e intraexaminadores da medida da ADM da abdução do ombro em pacientes pós-AVE usando o exergame PhysioPlay™. **Método:** Treze voluntários com AVE crônico, com idade de 58,23 ± 9,96 anos (homens e mulheres), participaram deste estudo. Dois fisioterapeutas avaliaram a abdução do ombro usando goniometria e o exergame PhysioPlay™. Um reteste foi realizado uma semana depois. **Resultados:** Os resultados das análises utilizando o coeficiente de correlação intraclasse (CCI) mostraram excelente nível de confiabilidade inter e intraexaminadores (r> 0,90; p <0,05). A correlação de Pearson entre as medidas máximas obtidas na goniometria e o software PhysioPlay™ apresentou alta correlação (r> 0,90, p = 0,001). **Conclusão:** O Kinect associado ao exergame PhysioPlay™ apresentou excelente confiabilidade na captura da medida da ADM em comparação à goniometria convencional.

Palavras-chave: Acidente Vascular Cerebral, Reabilitação, Fisioterapia, Artrometria Articular

INTRODUCTION

Strokes are one of the leading causes of death and disability in adults.[1] According to the location of the lesion, the size of the area of inadequate perfusion, and the amount of collateral blood flow, dysfunctions such as anxiety, depression, motor, sensory, cognitive, and communication disorders are observed in patients following a stroke.[2]

A sensorimotor disorder might include somatosensory changes that impair movement control and joint stabilit.[1] During the stroke, the upper motor neuron is reached, with a change in muscle tone with sagging and weak muscles related to the glenohumeral joint. This flaccid period is followed by involuntary muscle hyperactivity, called muscle spasticity, which may progress to the development of fixed contractures or adhesive capsulitis. Such changes imply significant immobility, limitations in upper limb function, and delays in the rehabilitation of these patients.[3]

An important subsystem of the somatosensory system involves proprioception, which, when altered, impairs the feedback and control of the advancement of therapies, negatively influencing joint range of motion (ROM), stability movements, and coordination.[1]

The most commonly used instrument for measuring ROM is the universal goniometer. This tool should be used by an experienced therapist to decrease the risk of error during measurement. The results are stored manually, which makes it difficult to process the obtained data and offers little or no feedback to the patient.[4]

Following the creation of devices with motion sensors such as Kinect, exergames have been developed, which allow the player's body to interact with the virtual environment.[5] The camera located in the device can detect the individual and the points of the skeleton in real time; thus, it is a suitable tool for accurate evaluation and low cost physical rehabilitation because it captures the complete movement of the body and is comfortable for the patient to use.[6]

However, before new measuring instruments or evaluation tools can be employed in research or clinical applications, their reliability must be determined. Reliability is nothing more than the precision of a measure when replicated.[7]

OBJECTIVE

This study evaluates the inter-and intra-rater reliability of the ROM measurement of the shoulder abduction in post-stroke patients using PhysioPlay™ - software that generates visual biofeedback to the patient - enabling their interaction with a virtual environment during the movement of stimuli generated on the screen.

METHODS

Thirteen volunteers, aged 58.23 ± 9.96, participated in the study. Requirements for the volunteers were male and female chronic stroke survivors with resulting conditions lasting more than six months; aged 25 - 75 years; present with a good level of cognition as evaluated by the Mini Mental State Examination (MMSE); active shoulder abduction movements observed by previous evaluation; spasticity lower than two on the Ashworth Modified Scale (AMS) for the spastic upper extremity musculature; and no associated neurological pathologies and/or pathological conditions of the shoulder that are unrelated to the post-stroke event. All volunteers were required to sign the informed consent term before participating.

Range of motion

The evaluation was performed by two trained physiotherapists. First, the shoulder abduction goniometry was conducted with the patient positioned in orthostatism, with the upper limbs along the body, the axis positioned near the acromion, a fixed bar on the posterior axillary line, and the movable bar accompanying the abduction movement in the dorsal aspect of the arm (Grade 0°–180°).[4]

Next, an evaluation of the abduction movement of the shoulder was made using the PhysioPlay™ exergame. The data obtained after one play were considered measures of the shoulder's ROM (abduction). After the patient's registration, elements such as the duration of the session (60 seconds), the interval between the angles to reach (10 seconds), and the limb to work on (left or right depending on the involvement) were determined.

The Kinect sensor made an initial depth reading of the patient positioned in front of the sensor it. The captured data were sent to the computer to which the Kinect was connected and were available for consultation through the Software Development Kit (SDK, released by Microsoft).

The patient was considered to have reached the target when the angulation achieved the angles previously determined during the play, where one of the points was the maximum angle obtained in the goniometry. The information obtained was presented in a report generated at the end of each execution, which showed the angulations of the evaluated limb captured at every second of the game. An analysis of the report allowed the professional responsible for the evaluation to determine the highest angulation reached by each patient.[5]

A retest of all patients was performed one week later by the same evaluators.

Ethical Considerations

This research was approved by the Ethics Committee of UNIFAL-MG (CAAE: 58830816.0.0000.5142), respecting all the norms and guidelines of resolution 466/12 of the National Health Council (CNS). All the participants signed the Consent Form.

For statistical analysis, the Statistical Package for Social Science for Windows (SPSS, v. 20.0) software was used. The agreement of the intra- and inter-rater reliability results for the use of the PhysioPlay™ software was analyzed using Intraclass Correlation Coefficient (ICC) type 1.1 and type 1.2. The interpretation of the CCI was made according to Lexell and Downham,[8] which considers the following levels of reliability: <0.40 = poor; 0.40–0.75 = good; >0.75 = excellent.

A 95% Confidence Interval (CI) was calculated, with values above 0.709 considered excellent. The calculation of the Standard Error of the Mean (SEM) was performed using the formula SEM = Standard Deviation x √ (1-ICC). The minimum detectable change (MDC) was calculated using the formula MDC = 1.96 x Greater Standard Deviation x √ (2 [1- rteste-retest]).[8] A significance level (α) of 0.05 was used for all tests.

The maximum measures obtained in the goniometry and the PhysioPlay™ by the two evaluators were verified for data normality using the Shapiro Wilk test, and the calculated variables were compared using the Pearson Correlation to verify the strength of the correlation between the two methods; r values above 0.80 were considered high. A significance level (α) of 0.01 was set a priori for the correlations.

RESULTS

Table 1 near here presents the socio-demographic data, and Table 2 near here presents the mean values and standard errors from the variables obtained in the test and retest when using the PhysioPlay™ exergame.

Table 1. Values of means and standard deviation for the socio-demographic data of the sample

				Averages (SD)		
	Sex	**LA**	**TiL**	**Weight (kg)**	**Height (cm)**	**TL (months)**
Men	9	6(D)/3(E)	6(I)/3(H)	75.50 (13.67)	169.33 (6.24)	38 (21.08)
Women	4	4 (E)	4(I)	58.25 (4.44)	156.25 (8.17)	54 (45.30)

LA: affected side; D = right; E = left; TiL: lesion type; I = ischemic; H = hemorrhagic; TL: injury time

Table 2. Mean values and standard error of the analyses obtained with the PhysioPlay™ by examiners 1 and 2 (test-retest)

	Averages (EP)			
	Rater 1	**Rater 2**	**Retest 1**	**Retest 2**
ABD-A(º)	78,40 (9,11)	81,55 (8,80)	78,28 (8,66)	77,65 (8,86)

ABD-A: Abduction of the affected side

In the ICC analysis, the level of reliability between inter-examiner and intra-examiner was excellent (r > 0.75) for all variables obtained (p < .05), as demonstrated in Table 3.

Table 3. Intra-class correlation (ICC) values intra and inter rater according to the measurements obtained for abduction of the affected shoulder

	INTRA EXAMINER		INTER EXAMINER	
	TEST/RETAIL AV1	TEST/RETAIL AV2	TEST AV1 AV2	RETEST AV1 AV2
CCI	0,992	0,985	0,992	0,996
IC 95%	0.975–0.998	0.945–0.996	0.968–0.998	0.986–0.999
EP	2,94	3,91	2,94	2,02
MMD	8,15	10,84	8,15	5,60
Level	E	E	E	E

ICC: Intraclass correlation coefficient; 95% CI: 95% confidence interval; EP: Standard error; MDD: Minimum Change Detectable

Table 4 near here presents the results of the Pearson Correlation between the maximum mean obtained from the goniometry and PhysioPlay™ in the test and retest. All results show high correlations (r > 0.80).

Table 4. Pearson correlation between the two methods used for evaluation, r and p

Variable	Comparison	r	*p*	Correlation
Abduction ofshoulder (side affected)	Physio/Gonio Appraise 1 Test	0,930	0,01	High
	Physio/Gonio Appraise 2 Test	0,943	0,01	High
	Physio/Gonio Appraise 1 Retest	0,971	0,01	High
	Physio/Gonio Appraise 2 Retest	0,920	0,01	High

DISCUSSION

The present study originated from the need to develop a tool capable of accurately and reliably evaluating the range of shoulder movement in a simple, low cost, and practical way, since the measurement of this measure is extremely important for recognizing abnormal movement, determining effective therapies, and obtaining significant improvement for the patient.

As reported in the literature, Kinect presents significantly accurate results for reading the human skeletal movement, including the upper limbs, making it a useful tool for the clinical measurement of ROM.[1] However, while many studies have shown the usefulness of the Kinect associated with software for static amplitude measurement, few have evaluated the active movement of the shoulder joint.[9]

In this study, the dynamic amplitude evaluation of PhysioPlay™ is capable of capturing every second of a patient's active movement from the beginning of the movement to its maximum performance, thus demonstrating increased efficacy compared to the data collected by goniometry.

The results of the statistical analyses showed excellent inter- and intra-rater correlations in the initial evaluation and in the retest, demonstrating that the Kinect was capable of accurately capturing movements with little variation between the evaluations by showing a reliable angle measurement.

In addition, the presentation of the PhysioPlay™ exergame makes the assessment more dynamic when compared to goniometry due to visual biofeedback, responsible for the correct achievement of the movement.

In a study performed with 10 healthy individuals, shoulder ROM was measured in four static poses using the goniometer and the Kinect sensor, followed by point-to-point measurements using the Kinect while the patient performed the movement as naturally as possible. An excellent correlation was observed between the measurements obtained using the Kinect and goniometry, and in the quality of movement captured by the sensor.[9]

A previous study examined 20 women after a mastectomy to evaluate the correlation between the Kinect measurement and goniometry. The women were positioned in front of the camera and asked to perform passive and active movements. The results showed a good relation between the two methods (r = 0.70–0.80), thus demonstrating the ability to capture the movement and determine its limitations.[10]

Another study compared Kinect measurements with photogrammetry by assessing the active shoulder motion of 20 healthy youths. The results showed a positive correlation between the evaluated methods and emphasized the practicality and agility of the measurement using the Kinect sensor.[11] Although the Kinect evaluation is dynamic, a specific exergame has not been developed and evaluated, thus motivating the intention of the exergame developed in the current study, since it is possible to collect data quickly and dynamically, store the data, and transport the instrument.

A study of healthy adolescents aged 12 to 17 were evaluated using Shriners Hospital for Children Upper Extremity Evaluation (SHUEE), a scale that measures the individual's ability to perform functional tasks, and the Kinect. The objective was to develop a set of scores of the function for the upper limb, similar to those assessed by SHUEE, but in an automated way using the Kinect. It was concluded that the Kinect motion analysis platform is technically solid and can be applied for upper-end evaluations based on standardized tasks.[12]

The results of the present study demonstrate the efficacy of Kinect, associated with exergame PhysioPlay™, in the evaluation of the ROM of the shoulder abduction in the sample studied. In addition, the individuals evaluated showed greater motivation to reach the maximum ROM. The results encourage the use of this practical and low-cost instrument in clinical practice and contribute information to new studies that incorporate the Kinect sensor associated with gaming in the evaluation and treatment of neuro-musculoskeletal dysfunctions.

Limitations of the study

The limitations of the study were the small number of patients evaluated and who fit the inclusion criteria. We suggest future studies use a larger sample and implement a standardized distance between the patient and the Kinect sensor.

CONCLUSIONS

The Kinect associated with the PhysioPlay™ presented high reliability in capturing the ROM measurement in a fast, simple, safe, and easy way.

ACKNOWLEDGMENT

To the Federal University of Alfenas UNIFAL-MG, University Center of the Guaxupé Educational Foundation – Unifeg, to the collaborators and patients.

Financing source

This work was supported by the Coordination of Improvement of Higher Level Personnel – CAPES.

REFERENCES

1. Santos GL, Souza MB, Desloovere K, Russo TL. Elastic tape improved shoulder joint position sense in chronic hemiparetic subjects: a randomized sham-controlled crossover study. PLoS One. 2017;12(1):e0170368. DOI: http://dx.doi.org/10.1371/journal.pone.0170368

2. Song J, Kim OY. Galanin's implications for post-stroke improvement. Anat Cell Biol. 2016;49(4):223-230. DOI: http://dx.doi.org/10.5115/acb.2016.49.4.223

3. Martens G, Laureys S, Thibaut A. Spasticity Management in Disorders of Consciousness. Brain Sci. 2017;7(12):162. DOI: http://dx.doi.org/10.3390/brainsci7120162

4. Marques AP. Manual da goniometria. 3 ed. Barueri: Manoele; 2014.

5. Oliveira RF. Shoulderforce: um exergame para reabilitação física aplicando a interatividade do kinect como biofeedback visual [Monografia]. Alfenas (MG): Universidade Federal de Alfenas; 2015.

6. Shih MC, Wang RY, Cheng SJ, Yang YR. Effects of a balance-based exergaming intervention using the Kinect sensor on posture stability in individuals with Parkinson's disease: a single-blinded randomized controlled trial. J Neuroeng Rehabil. 2016;13(1):78. DOI: http://dx.doi.org/10.1186/s12984-016-0185-y

7. Koo TK, Li MY. A Guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med. 2016;15(2):155-63. DOI: http://dx.doi.org/10.1016/j.jcm.2016.02.012

8. Lexell JE, Downham DY. How to assess the reliability of measurements in rehabilitation. Am J Phys Med Rehabil. 2005;84(9):719-23. DOI: http://dx.doi.org/10.1097/01.phm.0000176452.17771.20

9. Zulkarnain RF, Kim GY, Adikrishna A, Hong HP, Kim YJ, Jeon IH. Digital data acquisition of shoulder range of motion and arm motion smoothness using Kinect v2. J Shoulder Elbow Surg. 2017;26(5):895-901. DOI: http://dx.doi.org/10.1016/j.jse.2016.10.026

10. Gritsenko V, Dailey E, Kyle N, Taylor M, Whittacre S, Swisher AK. Feasibility of Using Low-Cost Motion Capture for Automated Screening of Shoulder Motion Limitation after Breast Cancer Surgery. PLoS One. 2015;10(6):e0128809. DOI: http://dx.doi.org/10.1371/journal.pone.0128809

11. Matsen FA 3rd, Lauder A, Rector K, Keeling P, Cherones AL. Measurement of active shoulder motion using the Kinect, a commercially available infrared position detection system. J Shoulder Elbow Surg. 2016;25(2):216-23. DOI: http://dx.doi.org/10.1016/j.jse.2015.07.011

12. Rammer JR, Krzak JJ, Riedel SA, Harris GF. Evaluation of upper extremity movement characteristics during standardized pediatric functional assessment with a Kinect®-based markerless motion analysis system. Conf Proc IEEE Eng Med Biol Soc. 2014;2014:2525-8. DOI: http://dx.doi.org/10.1109/EMBC.2014.6944136