ORIGINAL ARTICLE

Reliability of the PhysioPlay™ device for assessing the reaction time of cancer patients

Confiabilidade do dispositivo PhysioPlay™ para avaliar o tempo de reação de pacientes com câncer

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ABSTRACT

Objective: To determine the intra-evaluator and inter-evaluator reliability of the Physioplay-Kinect interaction and Trigno device for assessing the reaction time (RT) of cancer volunteers undergoing treatment. **Methods:** 46 cancer volunteers who underwent treatment modalities participated and were allocated into three groups: Chemotherapy Group (CG), Radiotherapy Group (RG), and Chemotherapy-Radiotherapy Group (CRG). The RT for all volunteers was assessed using the PhysioPlay™ and Trigno device. **Results:** In the intra-evaluator analysis, excellent levels of reliability (Physioplay: ICC> 0.99; Trigno 8: ICC>0.92) were observed in all groups. In the inter-evaluator analysis, excellent levels of reliability were observed in the CG (Physioplay: ICC= 0.98; Trigno 8: ICC= 0.98); excellent (Physioplay: ICC= 0.98) and good (Trigno 8: ICC= 0.44) levels in the RG; good (Physioplay: ICC= 0.49) and reasonable (Trigno 8: ICC= 0.29) levels in the CRG. **Conclusion:** The PhysioPlay™ and Trigno device proved to be reliable for assessing the RT of cancer volunteers undergoing treatment.

Keywords: Neoplasms/Rehabilitation, Video Games, Virtual Reality, Reaction Time

RESUMO

Objetivo: Determinar a confiabilidade intra-avaliador e inter-avaliador da interação Physioplay-Kinect e do dispositivo Trigno para avaliar o tempo de reação (TR) de voluntários com câncer em tratamento. **Métodos:** 46 voluntários com câncer em tratamento participaram do estudo e foram distribuídos em três grupos: Grupo de Quimioterapia (GQ), Grupo de Radioterapia (GR), e Grupo de Quimioterapia-Radioterapia (GQR). O TR para todos os voluntários foi avaliado utilizando o dispositivo PhysioPlay™ e Trigno. **Resultados:** Na análise intra-avaliador, foram observados excelentes níveis de confiabilidade (Physioplay: ICC> 0,99; Trigno 8: ICC>0,92) em todos os grupos. Na análise inter-avaliador, foram observados excelentes níveis de confiabilidade no GQ (Physioplay: ICC= 0,98; Trigno 8: ICC= 0,98); excelente (Physioplay: ICC= 0,98) e bom (Trigno 8: ICC= 0,44) níveis no GR; bons (Physioplay: ICC= 0,49) e razoáveis (Trigno 8: ICC= 0,29) níveis no GQR. **Conclusão:** Os dispositivos PhysioPlay™ e Trigno provaram ser confiáveis para avaliar o TR de voluntários com câncer em tratamento.

Palavras-chave: Neoplasias/Reabilitação, Jogos de Vídeo, Realidade Virtual, Tempo de Reação

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INTRODUCTION

Reaction time (RT) is the time required for an individual to perceive an external stimulus and respond to it.[1] Therefore, it involves the identification, interpretation, and preparation of the response, as well as the actual motor action.[2] For RT to exist, the stimulus must reach the primary somatosensory cortex via the afferent pathway to the posterior parietal cortex.[3] Next, the information is forwarded to area 6 of the motor cortex, where movement planning takes place (a pre-motor process). Then, the information progresses to area 4 of the motor cortex, beginning the preparation of the movement. In this stage, the cerebellum is important, because it guides the future action. Depending on the way in which cortical excitation occurs, the RT can be fast or slow.[4]

The type of stimulus can also influence RT. Stimuli can be classified as simple, in which there is a single response to a single stimulus; choice, in which there are different responses to different stimuli; and discrimination or selection, in which one should choose the most appropriate response while experiencing different stimuli.[5] Studies indicate that an individual's mood can also interfere with RT. A patient in a positive mood generally reacts more quickly, while a patient in a negative mood generally reacts more slowly.[6] In addition, the more practical patients has, the faster their RT will be.[7] Other factors can influence the speed of RT and, consequently, the speed of the motor response, including a patient's age (individuals between 20 and 30 years of age perform better),[8] type of training,[9] sex (males are faster), physical conditioning,[10] cognitive level, and fatigue level. Therefore, if any of these factors are altered, the RT will be affected accordingly.[7]

Recent advances in the development and administration of antineoplastic therapy have allowed patients to extend their lives. However, the incidence of symptoms related to toxicity affecting the nervous system, especially the peripheral nervous system (PNS), has increased.[11]

Chemotherapy-induced peripheral neuropathy (CIPN) is one of the most common side effects of antineoplastic therapy, affecting up to 85% of patients treated with chemotherapy. CIPN has a prevalence of approximately 68.1% when measured in the first month after chemotherapy, 60% after 3 months, and 30% after 6 months. It is a mainly sensory neuropathy that can be accompanied by motor and autonomic changes of different intensities and duration,[12] varying according to the different classes of drugs taken, depending on their specific physical and chemical properties and their dosages.[13] In addition to sensory symptoms, motor symptoms characterized by distal weakness, gait and balance disorders, and impaired movements may appear,[12] which can directly affect the RT of a patient, since factors such as physical conditioning[10] and level of fatigue are related to this deficit.[7]

The association between these symptoms can also interfere with a patient's treatment adherence and even limit the effects of active anti-tumor treatment. Therefore, the development of effective integrated treatment strategies should be encouraged,[14] involving the use of psychoeducational interventions and exercise programs associated with pharmacological treatments aimed at the physical and emotional well-being[15] and quality of life of the cancer patient.[16] The PhysioPlay™ software uses a three-dimensional virtual environment that promotes the sensory and motor integration of a patient through the Kinect® sensor. The system presents an innovative, simple, practical, functional, low-cost tool for the aim of being used as a tool for physical assessment and rehabilitation. The feature needs to be installed on a computer, one of its advantages being the low use of storage, in addition to being easily transportable. It can also be used to assess range of motion,[17] proprioception, and RT.

The Trigno 8 Channel Wireless device (EMGworks, Delsys Inc.) has an accelerometry evaluation system that can be used to evaluate the RT of a given movement. The accelerometer is an instrument used to capture movements and to evaluate their acceleration, frequency, duration, and intensity.[18] For our knowledge, no studies have been conducted to assess the reliability of this device.[19]

Currently, virtual reality has been used as a complementary alternative to the treatment of cancer-related fatigue. It is an interface that simulates a real environment and allows participants to interact with complex representations of objects.[20] Studies have demonstrated that virtual reality exergames efficiently reduce fatigue in people with cancer and increase muscle strength in the lower limbs.[16] Few studies has been conducted to analyze RT through virtual systems. Therefore, this study is the first to assess RT in cancer patients undergoing treatment.

OBJECTIVE

The aim of the study was to evaluate intra-evaluator and inter-evaluator reliability of the Kinect and Trigno 8 Channel Wireless device for assessing the reaction time (RT) of volunteers with cancer undergoing treatment.

METHODS

This is a cross-sectional study carried out from September 1, 2018 to January 30, 2020. The volunteers were selected in a single step by an evaluator (Evaluator 1), who subsequently analyzed the selected data twice with an interval of one month between the respective analyses. The data were delivered to a second evaluator (Evaluator 2) to continue the analysis. The reliability assessment was tested by means of an intra-evaluator (Evaluator 1.1) and inter-evaluator (Evaluator 1.2) simultaneously.

Volunteers were included if they were diagnosed with cancer and undergoing chemotherapy and/or radiotherapy treatment, aged between 18 and 80 years, of both sexes, and treated at Casa do Café of Associação Vida Viva and the Oncology Center of Santa Casa of Alfenas. Volunteers who were not undergoing treatment or who were under other modalities were excluded. Volunteers with dysfunctions in the upper and lower limbs, with cognitive difficulties regarding the execution of the requested movements, with myopathies, with neurological abnormalities unrelated to cancer treatment, and who for personal reasons did not want to participate or who refused to sign the informed consent form were also excluded.

All volunteers were assessed for RT by the same examiner, who had previously trained with the PhysioPlay™ and Trigno 8 Channel Wireless assessment device. The examiners (physiotherapists) had experience with virtual reality and surface electromyography, and both received training sessions

to familiarize themselves with the devices used in the evaluation.

To evaluate the RT of the volunteers with cancer undergoing treatment, we used a PhysioPlay™ (UNIFAL-MG, Brazil) software connected to a Kinect sensor (Microsoft) to capture their movements. Initially, all volunteers received guidance on how to use the instrument. The evaluation was performed unilaterally with the dominant limb.

To standardize the patient's position in front of the Kinect sensor, the volunteer was placed in an orthostatic position on a fixed mark on the floor and instructed to perform flexion movements and shoulder joint abductions. These movements were evaluated three consecutive times for a period of 60 seconds each, with a recording time interval of 0.1 second. The first iteration was used for teaching. The second was used to fix the activity. The third was used for the real validation of the data. Each time, the verbal commands "Raise your arm" or "Lower your arm" were given. The two angles requested were 30° and 45°. These actions lasted 10 seconds and were repeated sequentially.

For the data analysis, the difference between the moment in time when the volunteer started the movement toward the requested angle and the moment when the limb stabilized was recorded in seconds, whether or not the volunteer reached the correct angle. Microsoft Excel 2007 software was used to extract the collection data.

The Trigno 8 Channel Wireless device (EMGworks, Delsys Inc.) was also used to assess the RT of the volunteers with cancer undergoing treatment. Electrodes were positioned on the dorsal surface of the wrist and in the volunteer's middle deltoid region. The signal acquisition mode was calibrated at a sampling frequency of 1000 Hz with a gain of 1000 times filtered through 20 Hz high-pass filters, a 500 Hz low-pass filter, and a 60Hz filter to prevent interference from the power grid.

To collect the data, EMGworks Acquisition, version 4.7.6 was used. For the analysis of the collected data, EMGworks Analysis was used. The evaluation procedure was synchronized for a single trigger of the PhysioPlay™ and Trigno 8 Channel Wireless device.

For the statistical analysis of the data, the Statistical Package for the Social Sciences (SPSS) (IBM Corp., Chicago, USA), version 20.0 software was used. The data were expressed as descriptive statistics, particularly the mean, standard error, and confidence interval (95% CI) values. Then, the normality was tested using the Kolmogorov-Smirnov test.

To determine the reliability of the two instruments, the intraclass correlation coefficient (ICC) was used by the intra-evaluator (1.1) and inter-evaluator (1.2) for the RT in relation to the requested angles. In the interpretation of the ICC, the reliability was considered excellent for values ranging from 1.0 to 0.81, very good for values ranging from 0.80 to 0.61, good for values ranging from 0.60 to 0.41, reasonable for values ranging from 0.40 to 0.21, and poor for values ranging from 0.20 to 0.00.[21]

To differentiate between the real change and the random measurement error, standard error of measurement (SEM) and minimal detectable change (MDC) values were obtained. These data were calculated from the following equations: EPM = largest standard deviation x √ (1-ICC) and MDC = 1.96 x SEM x (√2). The MDC value represented the minimum amount of change needed to be considered a real hange or a change in which the real changes would be greater than the contributions of the random measurement error.[22]

A Bland-Altman agreement analysis was also conducted to verify the results. In this analysis, the difference between the values obtained by the PhysioPlay™ and Trigno device for each individual and the average value obtained in each instrument were calculated.

These two variables, the difference and average between the instruments, are presented in the dispersion graph. The mean and standard deviation resulting from the differences between the instruments were used to establish the upper and lower limits of agreement with the following equation: mean difference ± 1.96 x standard deviation. In the agreement analysis, 95% of the data fell between the upper and lower limits of agreement ($p < 0.05$).[23]

This study complied with the ethical principles contained in the Declaration of Helsinki, as well as the approval of the Research Ethics Committee of the University of Sapucai Valley (Protocol nº 3,466,787). The volunteers were informed about the evaluation protocols. After agreeing to participate, all signed the Free and Informed Consent Form.

RESULTS

This study included 46 volunteers who were divided into three groups: the Chemotherapy Group (CG; n: 26), the Radiotherapy Group (RG; n: 13), and the Chemotherapy-Radiotherapy Group (CRG; n: 7). The demographic and clinical data for the study participants are presented in Table 1.

Table 1. Sociodemographic and clinical characteristics of groups of volunteers submitted to three treatment modalities

CHARACTERISTICS	CG (n: 26) MEAN (SE)	RG (n: 13) MEAN (SE)	CRG (n: 7) MEAN (SE)	p
Age (years)	57,50 (2,64)	66,00 (3,58)	54,33 (4,58)	0,06
Height (m)	1,60 (0,03)	1,67 (0,02)	1,57 (0,04)	0,46
Body mass (kg)	65,61 (2,86)	68,11 (4,48)	68,50 (6,46)	0,21
	n (%)	n (%)	n (%)	
Gender | Female	14 (53,84)	4 (30,76)	6 (47,82)	<0,001
Male	12 (46,15)	9 (69,23)	1 (14,28)	
Number of sessions	25,92 (4,53)	16,08 (1,89)	17,21 (1,60)	0,27
Treatment modality	26 (56,52)	13 (28,26)	7 (15,21)	-
Types of cancer				
Mouth	-	1 (7,69)	-	-
Esophagus	1 (3,84)	-	1 (14,28)	-
Stomach	2 (7,69)	-	-	-
Liver	1 (3,84)	-	-	-
Pancreas	1 (3,84)	-	-	-
Intestine	-	-	1 (14,28)	-
Rectal	1 (3,84)	1 (7,69)	1 (14,28)	1
Breast	7 (26,92)	2 (15,38)	2 (28,57)	0,36
Uterus	1 (3,84)	-	-	-
Ovary	1 (3,84)	-	-	-
Prostate	1 (3,84)	9 (69,23)	1 (14,28)	0,03*
Bladder	1 (3,84)	-	-	-
Lung	2 (7,69)	-	-	-
Lymphoma	2 (7,69)	-	-	-
Leukemia	3 (11,53)	-	-	-
Bones	2 (7,69)	-	1 (14,28)	-

*CG: Chemotherapy Group; RG: Radiotherapy Group; CRG: Chemotherapy-Radiotherapy Group; n: number of volunteers; SE: Standard Error; m: meters; Kg: kilogram; *p<0,05 by chi-square test*

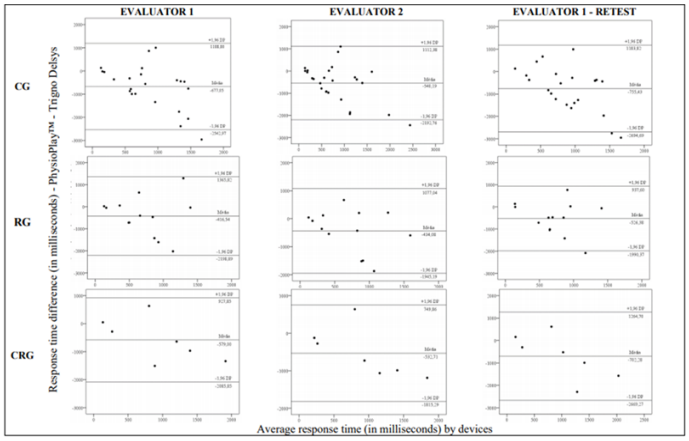
The analyses carried out allowed us to affirm, based on the characterization of the groups regarding age, height, body mass, gender, and cancer diagnosis, that the individuals were susceptible to comparison. Table 2 presents the mean values and standard error for the RT evaluation, measured in milliseconds by the PhysioPlay™ and Trigno 8 Channel Wireless device.

Table 2. Average values (standard error) the reaction time obtained in milliseconds of PhysioPlay™ and Trigno 8 Channel Wireless evaluation instruments according to the groups in their respective analyses

ANALYSES	VARIABLES	CG	RG	CRG
EVALUATOR 1	PHY (ms)	551,72 (107,43)	448,44 (151,09)	737,17 (199,49)
	TRIG (ms)	1234,83 (180,72)	1064,56 (236,83)	1420,83 (342,45)
EVALUATOR 2	PHY (ms)	572,33 (117,75)	448,44 (151,09)	767,50 (167,44)
	TRIG (ms)	1018,00 (127,05)	963,44 (234,61)	1368,50 (329,16)
RETEST EVALUATOR 1	PHY (ms)	551,72 (107,43)	448,44 (151,09)	716,67 (197,52)
	TRIG (ms)	1366,06 (179,01)	1145,11 (191,11)	1562,33 (404,91)

CG: Chemotherapy Group; RG: Radiotherapy Group; CRG: Chemotherapy-Radiotherapy Group; PHY: PhysioPlay™; TRIG: Trigno; ms: millisecond

The ICC values, level of reliability, and MDC of the instruments and their respective groups are shown in Table 3. The dispersion graph for the Bland-Altman agreement analysis between the groups is presented in Figure 1. This analysis demonstrated that the results obtained by evaluator 1 and evaluator 2, including in the retests by evaluator 1, agreed with the results from the PhysioPlay™ and Trigno device.



CG - Chemotherapy group; RG - Radiotherapy Group; CRG - Chemotherapy-Radiotherapy Group

Figure 1. Analysis of agreement between methods by means of Bland-Altman graphical presentation

Table 3. Reliability analysis intra-evaluator and inter-evaluator through the Intraclass Correlation Coefficient (ICC) of PhysioPlay™ and Trigno 8 Channel Wireless evaluation instruments in the respective groups

		INTRA-EVALUATOR					INTER-EVALUATOR				
VARIABLES	GROUPS	ICC	95%CI	SEM	MDC	Level	ICC	95%CI	SEM	MDC	Level
PHY	CG	1	1,00 - 1,00	0	0	E	0,98	0,96 - 0,99	79,25	219,68	E
	RG	1	1,00 - 1,00	0	0	E	0,98	0,93 - 0,99	67,78	187,89	E
	CRG	0,99	0,87 - 1,00	49,69	137,73	E	0,49	-2,86	354,85	983,61	G
TRIG	CG	0,92	0,81 - 0,97	236,4	655,27	E	0,99	0,98 - 1,00	83,58	231,67	E
	RG	0,92	0,71 - 0,98	185,95	515,42	E	0,44	0,32 - 0,72	506,35	1403,53	G
	CRG	0,96	0,73 - 0,99	198,36	549,84	E	0,29	-1,49	768,67	2130,64	R

DISCUSSION

When assessing the quality of an instrument, its reliability should be one of the main criteria used, since that criterion is based on the consistency and reproducibility of the results for different users in different situations and under different conditions. The reliability of an instrument refers mainly to its equivalence, precision, stability, and internal consistency.[24]

The present study analyzed the intra- and inter-evaluator reliability of the PhysioPlay™ and Trigno when used to evaluate the RT of volunteers with cancer undergoing treatment. These volunteers were separated into three groups according to their therapeutic modalities, which included chemotherapy, radiotherapy, and chemotherapy-radiotherapy.

In a previous study, the Kinect was validated as an instrument for assessing RT in the elderly through tests and retests. In this study, elderly volunteers saw themselves represented as avatars on a television screen.[25] The present study, similarly to the previous study, demonstrated the feasibility of using this system to assess RT, regardless of the environment of use. The Trigno 8 Channel Wireless device was used as a comparison parameter, as it is a valid tool to assess shoulder movements and muscle activity during simple elevations and complex tasks of the upper limbs.[19]

Another method for evaluating RT was described by Pojskic et al.[1] who developed a wireless evaluation system with infrared light sensors that calculated the time between a light indicator being randomly selected and activated and a volunteer raising a hand to turn off the sensor. Similarly, the present study used visual feedback in its evaluation, as the target angle was presented on a screen, and the volunteer reached toward it while trying to maintain shoulder abduction.

In the intra-evaluator analysis of the three groups, the present study demonstrated the excellent reliability of both instruments. In the inter-evaluator analysis, the reliability for both instruments was excellent in the Chemotherapy Group; excellent and good for the PhysioPlay™ and Trigno used in the Radiotherapy Group, respectively; and good and reasonable for the PhysioPlay™ and Trigno used in the Chemotherapy-Radiotherapy Group, respectively. It should be noted that the

sample size of the Chemotherapy-Radiotherapy Group may have negatively influenced the results. Similarly, a study that compared the use of the Kinect sensor to the Vicon system showed high test-retest reliability for gait assessment.[26] Another study revealed that both instruments effectively captured more than 90% of the variation of all movements of an injured patient playing a game in a virtual environment.[27]

From the MDC obtained in the intra-evaluator analysis, the PhysioPlay™ software was more sensitive in capturing variations in the Chemotherapy Group and Radiotherapy Group. However, in the inter-evaluator analysis, the MDC increased, representing an important factor to be considered in future studies. This finding suggests the need for future studies to minimize errors by having the same evaluator collect data. When more than one evaluator is involved with data collection, the MDC should be evaluated, since that value is more expressive when evaluating volunteers who are being treated by chemotherapy and radiotherapy simultaneously. As evidence, was reported that patients submitted to this association of modalities presented greater alterations in their complete blood count exams when compared to patients who were submitted only to the radiotherapy modality.[28] In addition, 75% of the cancer patients in the study had reduced hemoglobin counts,[28] a factor responsible for causing anemia,[29] indicating a direct relationship with fatigue.[14]

The present study had one main limitation. The Chemotherapy-Radiotherapy Group was relatively small, which could limit the generalizability of the results, mainly in the inter-evaluator analysis of the evaluation instruments.

CONCLUSION

This study has shown that the PhysioPlay™ and Trigno 8 Channel Wireless device demonstrate intra- and inter-evaluator reliability when used to evaluate the reaction time of volunteers with cancer undergoing treatment, indicating that the PhysioPlay™ is an efficient and safe instrument for this type of treatment.

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