

Comparison of hemodynamic responses between conventional and virtual reality therapies in patients with heart failure admitted to an emergency room

Comparação da resposta hemodinâmica entre terapia convencional e realidade virtual em pacientes com insuficiência cardíaca internados na unidade de emergência

Comparación de la respuesta hemodinámica entre la terapia convencional y la realidad virtual en pacientes con insuficiencia cardíaca ingresados en urgencias

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ABSTRACT | This study aimed to evaluate and to compare the acute response, due to semi-immersive virtual reality (VR) and conventional therapies (CT), of hemodynamic parameters in hospitalized individuals admitted to an emergency unit for heart failure (HF). This is a viability study with 11 individuals subjected to sessions with and without VR. At CT, stretching, active or active-assisted exercises, and fractional inspiration were performed. In VR therapy (VRT), VR box glasses were used to promote VR relaxation associated with CT. The hemodynamic parameters evaluated were heart rate, systolic and diastolic blood pressure, oxygen saturation, and double product. To analyze them, Student's *t*- and Mann Whitney tests were used ($p < 0.05$). Comparing baseline and final evaluations showed no significant differences in the hemodynamic parameters of both groups ($p > 0.05$). Comparing absolute variations between CT and VRT also produced no significant differences between hemodynamic responses ($p > 0.05$). Results showed that administering VRT and CT promoted physiological changes in the responses of hemodynamic parameters in individuals with HF hospitalized in an

emergency unit without significant differences between the two interventions. This study suggests that VRT is a hemodynamically safe method for treating patients in emergency units.

Keywords | Emergency Service, Hospital; Hospitalization; Virtual Reality Exposure Therapy; Heart Failure.

RESUMO | O objetivo deste estudo foi avaliar e comparar a resposta aguda de parâmetros hemodinâmicos de acordo com o uso de realidade virtual (RV) semi-imersiva e terapia convencional (TC) em indivíduos internados no serviço hospitalar de emergência por insuficiência cardíaca (IC). Trata-se de estudo de viabilidade com 11 indivíduos submetidos a sessões de terapia com e sem o uso da RV. Na TC, os participantes realizaram alongamentos, exercícios ativos ou ativo-assistidos e inspiração fracionada. Já na terapia com realidade virtual (TRV) utilizou-se os óculos VR *box* - *virtual reality glasses* aplicando VR *relax* associado à TC. Os parâmetros hemodinâmicos avaliados foram: frequência cardíaca, pressão arterial sistólica e diastólica e saturação de oxigênio. Para análise, foram

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utilizados os testes t de Student e de Mann-Whitney ($p < 0,05$). Ao avaliar os parâmetros hemodinâmicos basal e final em ambos os grupos, não foi verificada diferença significativa entre os momentos ($p > 0,05$). Com relação à comparação das variações absolutas entre a TC e a TRV, não foi observada diferença significativa entre as respostas hemodinâmicas ($p > 0,05$). Os resultados demonstraram que a implementação da TRV e da TC promoveram alterações fisiológicas nas respostas dos parâmetros hemodinâmicos em indivíduos com IC hospitalizados em uma unidade de emergência, não havendo diferenças significativas entre as duas intervenções. O estudo sugere que a RV é um método hemodinamicamente seguro para aplicação em unidade de emergência.

Descritores | Serviço Hospitalar de Emergência; Hospitalização; Terapia com Exposição à Realidade Virtual; Insuficiência Cardíaca.

RESUMEN | El objetivo de este estudio fue evaluar y comparar la respuesta aguda de los parámetros hemodinámicos según el uso de realidad virtual (RV) semiinmersiva y terapia convencional (TC) en individuos ingresados por insuficiencia cardíaca (IC) en el servicio de urgencias de un hospital. Este es un estudio de factibilidad con la participación de 11 personas, quienes se

sometieron a sesiones de terapia con el uso de RV y sin este. En la TC, los participantes realizaron estiramientos, ejercicios activos o activos-asistidos e inspiración fraccionada. En la terapia de realidad virtual (TRV), utilizaron gafas VR *box virtual reality glasses* aplicando realidad virtual VR *relax* asociada a la TC. Los parámetros hemodinámicos que se evaluaron fueron los siguientes: frecuencia cardíaca, presión arterial sistólica y diastólica, y saturación de oxígeno. El análisis de datos utilizó las pruebas t de Student y de Mann-Whitney ($p < 0,05$). Al evaluar los parámetros hemodinámicos basales y finales en ambos grupos, se observó que no hubo diferencia significativa entre los momentos ($p > 0,05$). En cuanto a la comparación de las variaciones absolutas entre TC y TRV, no se observó diferencia significativa entre las respuestas hemodinámicas ($p > 0,05$). Los resultados mostraron que la implementación de la TRV y la TC posibilitó cambios fisiológicos en las respuestas de los parámetros hemodinámicos en individuos con IC hospitalizados en una unidad de urgencias, sin diferencias significativas entre las dos intervenciones. El estudio apunta que la RV es un método hemodinámico seguro para aplicarse en la unidad de urgencias.

Palabras clave | Servicio de Urgencia en Hospital; Hospitalización; Terapia con Exposición a Realidad Virtual; Insuficiencia Cardíaca.

INTRODUCTION

Among the most prominent causes of hospitalization in Brazil are cardiovascular diseases (CVD)¹, the main cause of death worldwide². Among them, heart failure (HF) deserves emphasis since it can decompensate clinical pictures and, consequently, require recurrent hospitalizations³. Thus, the demand for emergency unit service stands out worldwide⁴ and in Brazil⁵.

Physiotherapists are especially important in this scenario since they treat patients via conventional therapy (CT) whose early rehabilitation not only influences resource management but can also reduce the need for hospital readmission⁶ and length of stay in these units⁷, as well as improve quality of life⁶.

In this context, technological therapeutic options are ever more important in hospital units⁸. Virtual reality (VR) is one of the most advanced technologies used as an alternative tool to rehabilitation since it helps treating several pathologies and can bring multiple benefits⁹⁻¹⁴, such as improvement to functional capacity¹¹ and pain reduction after procedures¹⁴.

Moreover, it alters signal pathways involving attention, emotion, concentration, and memory, and

provides cognitive and affective changes by individuals' perception of a virtual environment¹⁵, increasing motivation¹⁶ during treatment via entertainment and fun. This new technology encourages individuals to act in a virtual environment while maintaining them in the real world. Immersive VR promotes real-time interactivity via helmets, projection rooms, and other multisensory devices^{17,18}.

Due to its positive results in reducing tiredness and increasing energy and pleasure, VR was considered favorable to treat different health conditions in individuals hospitalized in an intensive care unit⁸. Thus, it is of paramount importance to assess the safety of this alternative method, evaluating the hemodynamic responses of patients with HF, who were hospitalized in an emergency unit and subjected to VR.

We explore this new therapeutic resource in this study, allowing new perspectives of physiotherapists' performance with modern and alternative techniques to be increasingly indicated in hospitals. What is essential for this new treatment is motivating patients to assist their recovery¹⁴, diversifying the therapeutic environment to mitigate

the psychological effects of hospitalization and possibly enhance individuals' capacities.

Thus, this study aimed to evaluate and compare the hemodynamic responses to semi-immersive VR with those to CT in individuals hospitalized in an emergency hospital service due to HF. Our research hypothesis is that semi-immersive VR provides physiological responses to hemodynamic parameters which fail to differ from CT ones in individuals hospitalized with HF.

METHODOLOGY

Ethical aspects

This study is in line with Resolution no. 466/2012 of the National Health Council. Participants were instructed on the procedures they would perform and signed informed consent forms. This study was published in the Brazilian Registry of Clinical Trials (ReBEC) under number RBR-6y69tqv.

Sample characterization

This feasibility study was conducted in an emergency unit of a hospital in the state of São Paulo, with a convenience sample of 22 individuals of both genders⁸, admitted to the hospital emergency service.

The sample included patients of all genders, aged 43 years or older, who were hospitalized in an emergency unit due to HF and prescribed motor and respiratory physiotherapy. We excluded patients who required vasoactive medication, showed mean blood pressure below 65 or above 120mmHg, heart rate below 50 or above 140bpm, respiratory rate above 35ipm, acute clinical worsening, and drowsiness or who were either non-collaborative, unable to follow commands¹⁹, in contact precaution or orotracheal intubation.

To characterize our sample, clinical diagnosis of admission, etiology, and classification of HF were collected according to ejection fraction³. Eligible subjects were selected for CT and virtual reality therapy (VRT) sessions. Before the first session, randomization was conducted by an independent researcher who had no previous contact with participants. Thus, to determine the sequence of the sessions, a raffle was performed with sealed brown envelopes to ensure allocation confidentiality. Two envelopes with one of the therapies were used. Each individual chose an

envelope, thus determining which therapy would be performed first. Depending on what was determined by randomizing the sequence of sessions, the first session – CT or RVT – was performed on the second day of hospitalization in the emergency hospital. The second one – CT or RVT – occurred 24 hours after the first session, i.e., on the third day of hospitalization in the emergency hospital.

Before and immediately after both treatments, patients' hemodynamic parameters were evaluated: heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), oxygen saturation (SpO₂), and double product (DP).

Conventional therapy treatment

Patients who were subjected to CT participated in sessions with an average duration of 24 minutes. At the beginning of the session, passive or active static stretching of deltoid muscles, brachial and sural triceps, hamstrings, and glutes was performed, according to individuals' capabilities. Stretching was supervised by a physiotherapist, and positions were maintained for 15 seconds²⁰. Next, a session was performed with a series of 10 repetitions of passive or active-assisted exercises of shoulder flexion; elbow, knee, ankle, and wrist flexion-extension; radial and ulnar deviation; hip flexion; inversion-eversion^{19,21}, and fractional-inspired breathing exercises²².

Virtual reality therapy treatment

RVT was performed via reality glasses (VR box - China) and the VR relax app, which transmits the immersive sensation of observing a sandy beach to patients. Sessions lasted, on average, 33 minutes, and individuals performed the same procedures as conventional therapy ones. The glasses have a foam that attaches the phone to its lid, with some bands keeping the accessory firm to users' heads after attachment. It is worth mentioning that VRT sessions were interrupted in case of symptoms such as dizziness, vertigo, and malaise.

Hemodynamic parameters

HR was determined by the Polar heart rate monitor model S810i (Polar Electro, Finland)²³. SBP and DBP were assessed by the Premium[®] sphygmomanometer (*Wenzhou, Zhejiang, China*) and the Littiman[®]

stethoscope (class III model, St. Paul, Minnesota, USA), according to the 7th Brazilian Arterial Hypertension Guideline²³. SpO₂ was analyzed by a digital finger oximeter from Quanta OX-201. DP was obtained by multiplying HR (measured in bpm) by SBP (measured in mmHg)²⁴.

Statistical analysis

Data were expressed as means \pm standard deviations, percentage values, median, and interquartile range. Data normality was assessed by the Shapiro-Wilk test. For paired analysis, the paired Student's *t*- or Wilcoxon tests were performed in face of normality. Intergroup comparisons were analyzed by absolute variation before and after interventions, and unpaired Student's *t*- or Mann-Whitney tests were applied according to data normality. Significance levels

were set at 0.05%. The GraphPad Prism statistical software was used.

RESULTS

We recruited patients hospitalized in an emergency unit (n=22) to conduct this study. Of these, 11 were included in the analysis (Figure 1).

Of the 11 subjects evaluated, 54.54% (n=6) are older adults (age equal to or greater than 60 years)²⁵. In addition to HF diagnosis, all participants (n=11) showed comorbidities, such as systemic arterial hypertension, and 72.72% (n=8), diabetes mellitus (Table 1).

Comparing baseline and final hemodynamic parameters and absolute variations between CT and VRT (Table 2) groups showed no significant differences in HR, SBP, DBP, SpO₂, and SD ($p > 0.05$).

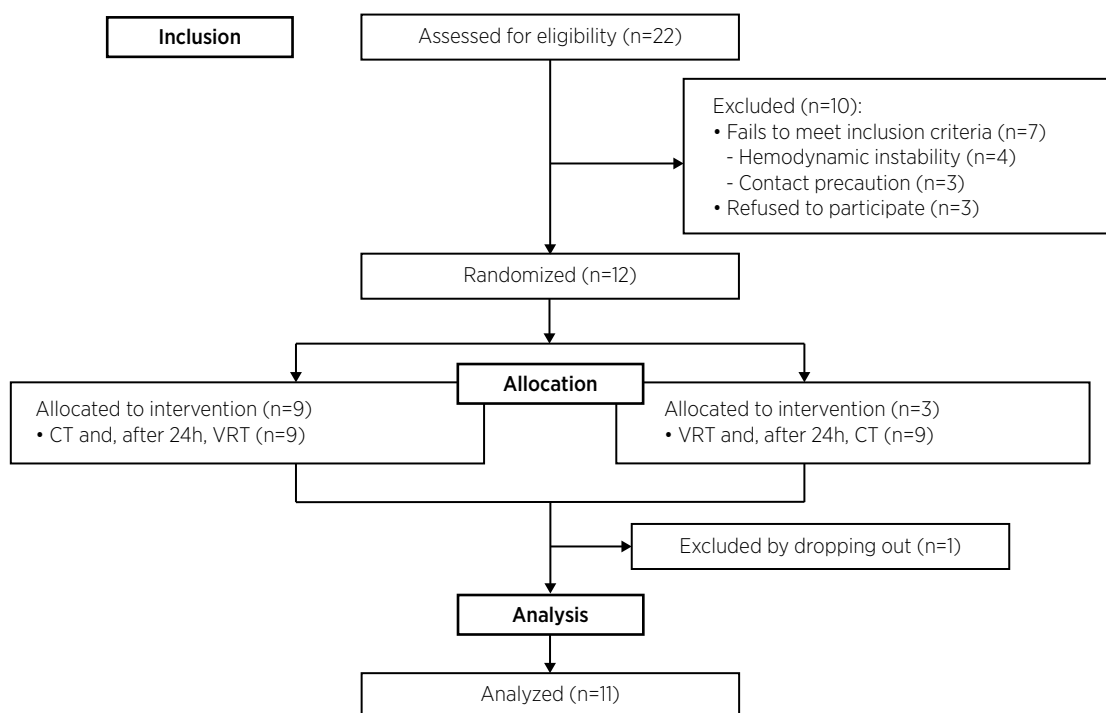


Figure 1. Allocation flowchart

Table 1. Patients' clinical characteristics, expressed as average \pm standard deviation or absolute value and percentage

Characteristics	(n=11)
Gender (M/F)	7/4
Age (years)	62.18 \pm 15.44
HF etiology	
Ischemic	27.27%
Hypertense	36.36%

(continua)

Tabela 1. Continuação

Characteristics	(n=11)
Chagas'	9.09%
Valvular	18.18%
Alcoholic	9.09%
HF classification	
Preserved EF ($\geq 50\%$)	27.27%
Moderate EF (40-49%)	9.09%
Reduced EF ($< 40\%$)	63.63%
Main comorbidities	
Systemic arterial hypertension	100%
Diabetes mellitus	72.72%

n: numbers of individuals; m: male; f: female; HF: heart failure; EF: ejection fraction.

Table 2. Comparison of absolute variations in hemodynamic parameters between virtual and conventional reality therapy groups expressed as median

Hemodynamic Parameters	Conventional Therapy	Virtual Reality Therapy	p-value
Δ FC (bpm)	2.00 [-2.00-4.00]	1.00 [-3.00-1.00]	0.1564
Δ PAS (mmHg)	0.00 [0.00-10.00]	0.00 [0.00-10.00]	0.5458
Δ PAD (mmHg)	10.00 [0.00-10.00]	0.00 [0.00-10.00]	0.5948
Δ SpO ₂ (%)	0.00 [0.00-1.00]	0.00 [0.00-1.00]	0.8242
Δ DP (bpm.mmHg)	560.00 [-500.00-1450.00]	[-200.00] [-650.00-830.00]	0.1398

Δ : Amplitude; HR: heart rate; bpm: beats per minute; SBP: systolic blood pressure; DBP: diastolic blood pressure; mmHg: mercury millimeters; SpO₂: oxygen saturation; DP: double product.

DISCUSSION

This study showed that VRT and CT promoted physiological changes in hemodynamic parameter responses but failed to significantly differ between training modalities.

The main finding of this study was the absence of differences between intervention types, CT and RVT, regarding HR, SBP, DBP, SpO₂, and DP. On the other hand, we showed that baseline hemodynamic values were within the reference values^{23,26-28} for both CT and RVT.

During the exercises, hemodynamic parameters changed, such as increased HR, SBP, and SpO₂ in both therapies. Although they fail to show statistical differences, we expected these changes since interventions affect physiological responses by increasing metabolic demands in relation to rest²⁸.

Cacau et al.¹⁴ also compared a conventional intervention with a VR one in individuals in phase I of

cardiovascular rehabilitation, subjected to elective surgery for myocardial revascularization and/or valve replacement, finding VR-related benefits to functional performance. Thus, our studies show that VR therapy is a safe treatment for hospitalized individuals.

Regarding hemodynamic parameters, Chuang et al.²⁹ evaluated individuals in phase II of cardiovascular rehabilitation who were subjected to VRT. The hemodynamic parameters they evaluated were training PA, HR, SpO₂, and HR, evidencing participants' improved cardiorespiratory capacity. Moreover, the VR-subjected group achieved predetermined goals quicker than the control group. Their difference with this study is due to the fact that the individuals Chuang et al.²⁹ evaluated are in phase II of cardiovascular rehabilitation, in which the prescribed exercises are more intense than those in this study.

Individuals hospitalized in the chosen emergency unit who were in phase I of cardiovascular rehabilitation performed low intensity and energy expenditure exercises between three and four metabolic equivalents³⁰. This activity aimed at early movement to reduce future hospital admissions, improve symptoms and quality of life³¹, evaluate clinical responses to progressive effort increase, and minimize cardiorespiratory complications since prolonged bed rest decreases muscle tone and functional capacity and increases HR and BP responses³².

Moreover, the numerous benefits of regular exercise and improved functional capacity for patients with heart disease are adaptation effects to physical training³², a long-term response.

As strengths of this study, we observed that the repercussions of both CT and VRT were within expected normal standards, suggesting that VRT can be used as a new therapy proposal in individuals hospitalized with

HF and since it is a playful therapy, we suggest that it can stimulate the participation of cardiovascular rehabilitation and contribute to treatment adequacy. However, its indication should consider measures such as selection of stable patients, greater monitoring of cardiovascular parameters, and, when necessary, guidance to patients on the correct way of performing the movements.

This study has limitations, such as its reduced sample and session duration. More studies are needed since this subject is still scarce in the literature.

CONCLUSION

Implementing VRT and CT promoted physiological changes in hemodynamic parameter responses in individuals with HF hospitalized in an emergency unit, with no significant differences between the two interventions. Thus, this study suggests that semi-immersive VR is a hemodynamically safe method applicable in emergency units.

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