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ORIGINAL ARTICLE

Effects of Conventional and Virtual Reality Cardiovascular Rehabilitation in Body Composition and Functional Capacity of Patients with Heart Diseases: Randomized Clinical Trial

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Abstract

Background: Virtual reality is an alternative therapeutic resource to be inserted into cardiovascular rehabilitation, stimulating the practice of physical activity through man-machine interaction.

Objective: To compare the effects of conventional and virtual reality cardiac rehabilitation on body composition and functional capacity in patients with heart disease.

Methods: Randomized clinical trial with 27 cardiac patients divided into conventional rehabilitation group (CRG) and virtual reality rehabilitation group (VRG). They underwent a rehabilitation program with 60-minute training sessions twice a week for eight weeks. The VRG training consisted of exercises from the Xbox 360® with Kinect™, using YourShape™ and Dance Central 3™ games. The CRG used conventional treadmills for aerobic exercise and free weights for resistance exercise. Bioimpedance and 6-minute walk test (6MWT) were evaluated at baseline and after training. For main outcome analysis, Student t and Mann Whitney tests were used with a 5% significance level.

Results: The VRG showed a significant increase in body fat percentage and fat weight when compared to the CRG, and a smaller amount of total water. There was a significant improvement in functional capacity evidenced by the increase in the distance covered in the 6MWT (54.00 m and 32.25 m in the CRG and VRG, respectively), but the gains did not differ between the groups.

Conclusion: The two rehabilitation modalities had no effect on the body composition of the groups. In addition, the improvement in functional capacity was similar in both groups. (Int J Cardiovasc Sci. 2018;31(6)619-629)

Keywords: Cardiovascular Diseases; Cardiac Rehabilitation; Physical Therapy Modalities; Body Composition; Virtual Reality Exposure Therapy.

Introduction

Cardiovascular diseases (CVD) are a major cause of mortality worldwide, with approximately 17.5 million deaths, accounting for three in every ten deaths.[1] In Brazil, despite the progressive decline in deaths due to CVD, they remain the major cause of hospitalization and mortality, accounting for 31.3% of adult deaths.[2,3]

Therefore, cardiovascular rehabilitation programs, by use of physical activity, are essential to improve cardiovascular function and aerobic capacity, in addition to providing psychological benefits, risk factor control, improvement in CVD symptoms and mortality reduction.[4-6]

The advance of cardiovascular rehabilitation has witnessed the incorporation of technology to its methods, with virtual reality (VR) being included into physical therapy protocols[7,8] to boost physical activity practice[9] and encourage the rehabilitation process.[10] Virtual reality uses devices that promote man-machine integration,

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allowing real-time three-dimensional movement.[11] The videogames that adopt physical interaction with the user are called "exergames"[12,13] and provide body motion as a form of exercise.[14]

Physical exercise influences physical fitness, whose components include flexibility, muscle strength, cardiorespiratory endurance and body composition.[15] The studies by Mandic et al.,[16] and Calegari et al.,[17] have shown that the regular practice of physical activity has favorable effects on the body composition and functional capacity of individuals with CVD. However, whether the VR intervention as a physical exercise modality has benefits similar to those of the cardiovascular rehabilitation process remains controversial. This study hypothesized that, after implementing conventional and VR cardiac rehabilitation, individuals have similar improvement in body composition and functional capacity.

This study aimed at comparing the effects of conventional and VR cardiac rehabilitation on the body composition and functional capacity of individuals with CVD. In addition, food frequency and blood glucose levels were assessed.

Methods

Ethical aspects

The individuals included in this study were informed about all the procedures and provided written informed consent to participate. This study was approved by the Ethics Committee of the institution (CAAE: 62437816.4.0000.5515) and abides by the CONEP resolution 466/2012. The registration of this randomized clinical trial can be found at Clinicaltrials.gov (NCT03169387).

Sample characterization

This is a parallel group randomized clinical trial conducted at the physical therapy clinic of the Oeste Paulista University (UNOESTE), in the city of Presidente Prudente, São Paulo, Brazil, from February to October 2017. The sample comprised 27 individuals divided into two groups: a conventional rehabilitation group (CRG) and a virtual reality rehabilitation group (VRG). Based on sample calculation, each group had at least 12 individuals, using the study by Pimenta et al. (2013)[18] as reference. Fat-free mass was used, with standard deviation of 4.02, difference to be detected of 3.8 for the two-tail hypothesis test, power of 80%, and significance level of 5%. Figure 1 shows the flow diagram of the participants in every phase of the study, in accordance with the recommendations of the CONSORT Statement.[19]

The random allocation sequence was generated by a researcher without previous contact with the participants by use of the Microsoft Office Excel® program, at an allocation ratio of 1:1.

The study included individuals over the age of 45 years, of both sexes, with CVD (coronary heart disease, postoperative period of coronary artery by-pass grafting, acute myocardial infarction, systemic arterial hypertension, diabetes mellitus). The inclusion criteria were as follows: hemodynamic stability (systolic blood pressure < 200 mmHg and diastolic blood pressure < 110 mmHg at rest, absence of angina, controlled arrhythmias, and resting heart rate < 120 beats per minute);[20] absence of arteriopathy and muscle or orthopedic changes; and no supervised physical activity in the previous 30 days. The exclusion criteria were as follows: decompensations (circumstances posing a risk to individual integrity) during the training protocol; lack of adaptation to the protocol; and participation frequency lower than 75%.

Experimental design

Participants underwent an initial evaluation to detect comorbidities, to establish the diagnosis, to collect the clinical history and medications used, and to measure the anthropometric variables. The following parameters were assessed before the intervention and eight weeks after that: body composition; waist circumference; food frequency; functional capacity; and blood glucose levels.

Anthropometric variables

Weight (in kilograms) was measured with a WELMY W300® scale (accuracy to the nearest 100 g), with the individual barefoot wearing light and comfortable clothes. Height (in meters) was measured with a Sanny® stadiometer (accuracy to the nearest 0.1 cm), with the individual barefoot, standing with his/her back to the height rule, feet together, head positioned in the Frankfurt plane, and the measuring rod lowered to the individual's head. Body mass index (BMI) was calculated based on weight and height (weight/height^2).

Body composition

Body composition was the study's primary outcome, and body fat percentage was defined as the primary variable. Body composition was assessed by use of

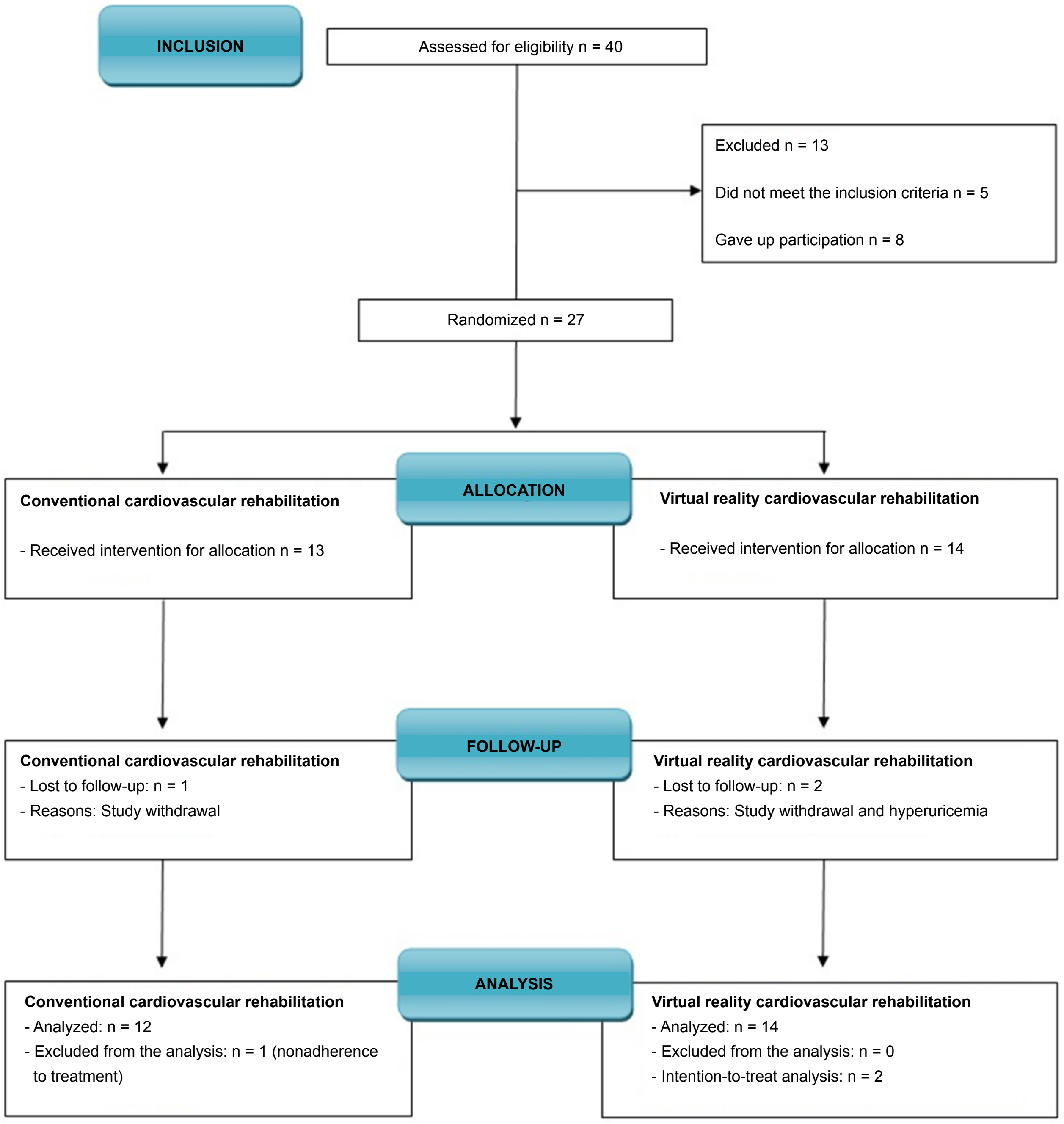

Figure 1 - Flow diagram of the participants in every phase of the study, in accordance with the recommendations of the CONSORT Statement.

bioimpedance analysis with a tetrapolar bioimpedance device (Biodynamics®, model 310e), analyzing and quantifying the body fat percentage, body fat weight, lean weight, basal metabolic rate, and percent and total water. Bioimpedance analysis measurements were taken in the morning, in fasting condition, after voiding the urinary bladder, having suspended diuretics for 24 hours, no alcohol and caffeine consumption for 24 hours, and no intense physical activity for 72 hours in both the initial and final assessment.[21,22]

Waist circumference

Waist circumference was measured with a non-distensible measuring tape (accuracy to the nearest 1 mm) and the subject standing, with parallel feet and arms hanging freely by the sides of the trunk. The measuring tape was placed in a horizontal plane around the abdomen, at the level of the umbilicus, just above the uppermost lateral border of the right iliac crest, not compressing the skin. Measurement (in centimeters) was taken three times, and the lowest value obtained was considered for analysis.[23]

Food frequency

The Food Frequency Questionnaire (FFQ) was used to assess the frequency of food consumption. The FFQ consists of a list of foods and beverages with response categories to indicate the frequency of consumption over the time queried. The frequency is registered in units of time (days, weeks, months or years) according to the need.[24]

Functional capacity

Functional capacity was assessed by use of the Six-Minute Walk Test (6MWT) performed according to the American Thoracic Society criteria.[25] The 6MWT was performed along a corridor of the UNOESTE gymnasium.

Blood glucose level

Postprandial capillary blood glucose level was assessed (milligram per deciliter) by use of an Optium Xceed® blood glucose meter that reads glucose in fresh capillary blood obtained by pricking the ring finger skin with a sterilized lancet. The measurements were taken before and after training in an individualized way.

Cardiovascular parameters

Heart rate was measured by use of a Sigma® cardiac frequency meter. Oxygen saturation was measured by use of a pulse oximeter (Choicemmed®, model Md300c1). With the subject in the sitting position, blood pressure was measured from the dominant arm, using a Premium® aneroid sphygmomanometer and a Littman® stethoscope, following the recommendations of the Brazilian guidelines on arterial hypertension.[26] The subjective perception of exertion was assessed by use of the Borg scale of perceived exertion.[27]

Training protocol

Both groups underwent 60-minute training sessions twice a week for eight weeks at the UNOESTE physical therapy clinic, adding up to 16 sessions. Four physical therapy students conducted the sessions, two for each group, and each student was responsible for two participants per session. In the initial and final 5 minutes, the following parameters were assessed: blood pressure, blood glucose level, oxygen saturation, and subjective perception of exertion by use of the Borg scale. During the entire session, the Borg scale was used and heart rate was assessed to ensure that the training heart rate calculated individually with the Karvonen formula would not be exceeded (50% to 80% of the reserve heart rate).[27,28]

The VRG training comprised the use of the Microsoft Kinect™ sensor for Xbox 360®, with a controller-free infrared camera that tracks user motion. Two games were used: Your Shape™ (Fitness Evolved) and Dance Central 3™. Your Shape™ (Fitness Evolved) is a program that allows users to exercise their upper and lower limbs in an isolated or combined way, and comprises mainly trunk rotation, diagonal flexion/adduction and extension/abduction movements, plantar flexion of ankle, hip flexion and squat. Dance Central 3™ is a music rhythm game involving performing given dance moves, which are tracked by Kinect. Both were performed for 25 minutes, the former in association with ankle Velcro weights and dumbbells as resistance. The increase in resistance was individualized and based on the Borg scale of perceived exertion (13: somewhat hard).[27]

The CRG training comprised the use of treadmills (Embreex®) for aerobic training for 30 minutes and free weights, with 1-4-kg dumbbells and 2-4-kg ankle Velcro weights, for resisted training, performed in three sets of 10 repetitions, with 1-minute recovery interval. The exercises comprised shoulder abduction, elbow flexion, knee extension and flexion, all performed in the sitting position, except for knee flexion, performed in the standing up position.[27] In the CRG training protocol, resistance was increased similarly to that in the VRG training protocol.

Statistical analysis

Data were assessed by use of the GraphPad Prism statistical software. Data normality of distribution was analyzed with Shapiro Wilk test. Proportion was compared by use of chi-square test. Paired analysis was carried out by use of paired Student t test in case of normal distribution or Wilcoxon test for non-normal distribution variables. Intergroup comparisons were performed by use of absolute variation before and after the interventions, and nonpaired Student t test or Mann Whitney test were used according to data distribution. The magnitude of the differences between groups was described by calculating the effect size, using Cohen's d. The effect sizes considered were as follows: small ($d \leq 0.2$), medium ($d = 0.5$), and large ($d \geq 0.8$). Continuous variables were expressed as mean and standard deviation or median and interquartile range, according to normal data distribution. Categorical variables were expressed as absolute and percentage values with their respective confidence intervals. The significance level adopted was 5%.

Results

Clinical and anthropometric data

Table 1 shows the clinical and anthropometric data of the individuals assessed, whose mean age was 63.46 ± 8.12 years, most of whom were of the male sex. There was no significant difference between groups regarding age and anthropometry. Systemic arterial hypertension was the major comorbidity. Anti-hypertensives were the most frequently used medication.

Body composition

Table 2 shows the baseline and final body composition of both groups. The VRG showed a significant difference regarding the increase in body fat percentage and in fat weight, in addition to a decrease in basal metabolic rate and total water, while the CRG showed no significant difference. Waist circumference did not significantly differ between CRG and VRG.

Table 3 compares the absolute variation in body composition between the groups, evidencing significant differences regarding body fat percentage and fat weight, which were higher in the VRG, while total water was significantly lower in the VRG than in the CRG. The other variables showed no significant difference. The effect size

Table 1 - Baseline clinical and anthropometric characteristics of the conventional and virtual reality rehabilitation groups (CRG and VRG, respectively) expressed as mean ± standard deviation or absolute and percent value

Characteristics	CRG n = 12	%	VRG n = 14	%	p value
Age (years)	63.75 ± 8.65		63.21 ± 8.27		0.8734
Weight (kg)	78.48 ± 16.86		72.43 ± 10.69		0.2785
Height (m)	1.629 ± 0.08		1.635 ± 0.079		0.8598
BMI (kg/m^2)	29.38 ± 4.80		27.02 ± 3.19		0.1491
Sex (m/f)	6/6	50/50	12/2	85.71/14.28	0.0492
Medications	**n**	**% / 95% CI**	**n**	**% / 95% CI**	
Antihypertensive agents	11	91.66 / 0.64-0.98	12	85.31 / 0.6-0.95	0.6358
Antiplatelet drugs	9	75 / 0.46 – 0.91	9	64.28 / 0.38 – 0.83	0.5551
Hypoglycemic agents	2	16.66 / 0.04 – 0.44	2	14.28 / 0.04 – 0.39	0.8668
Lipid-lowering drugs	8	66.66 / 0.39 – 0.86	10	71.42 / 0.45-0.88	0.7931
Beta-blockers	10	83.33 / 0.55 – 0.95	8	57.14 / 0.32-0.78	0.1492
Concomitant diseases	**n**	**% / 95% CI**	**n**	**% / 95% CI**	
SAH	11	91.66 / 0.64 – 0.98	13	92.85 / 0.68-0.98	0.9096
Diabetes mellitus	4	33.33 / 0.13 – 0.60	4	28.57/ 0.11-0.54	0.7931
AMI	8	66.66 / 0.39 – 0.86	6	42.85 / 0.21 – 0.67	0.2247

BMI: body mass index; m: male; f: female; n: number of individuals; CI: confidence interval; SAH: systemic arterial hypertension; AMI: acute myocardial infarction. Statistical tests: chi-square test to compare proportions, and nonpaired Student t test to compare continuous variables.

Table 2 - Body composition and waist circumference of the conventional and virtual reality rehabilitation groups (CRG and VRG, respectively) at baseline and study end, expressed as mean ± standard deviation

BIA / WC	CRG		p value	VRG		p value
	Baseline	Final		Baseline	Final	
Fat (%)	33.66 ± 4.83	33.25 ± 5.53	0.5271	28.34 ± 4.59	30.02 ± 4.28	0.0117*
Fat weight (kg)	26.27 ± 6.09	25.95 ± 6.9	0.5654	20.43 ± 4.1	21.79 ± 3.95	0.0191*
Lean weight (kg)	52.22 ± 12.62	52.33 ± 12.29	0.8512	51.87 ± 8.92	51.79 ± 9.08	0.9269
BMR (Kcal)	1605 ± 378.4	1591 ± 373.9	0.6638	1579 ± 269.4	1553 ± 276.6	0.0407
Water (%)	76.06 ± 1.50	72.99 ± 8.67	0.0664	76.16 ± 1.97	76.13 ± 1.83	0.8504
Total water (L)	39.73 ± 9.84	41.99 ± 14	0.3601	39.57 ± 7	38.61 ± 7.37	0.0241*
WC (cm)	102.2 ± 11.70	103.3 ± 12.64	0.3115	95.36 ± 8.758	96.64 ± 9.018	0.0823

*BIA: bioimpedance; WC: waist circumference; BMR: basal metabolic rate; * significant difference between study end and baseline. Statistical tests: paired Student t test or Wilcoxon test according to data normality.*

Table 3 - Comparison of the variations in body composition and waist circumference between the conventional and virtual reality rehabilitation groups (CRG and VRG, respectively) expressed as median and interquartile range (25%-75%)

BIA / WC	CRG	95% CI LL	95% CI UL	VRG	95% CI LL	95% CI UL	p value
Δ Fat (%)	0.10 [-1.87 - 1.32]	-1.784	0.9676	2.05 [0.75 - 3.00]	0.4408	2.916	0.0213*
Δ Fat weight (kg)	-0.30 [-1.70 - 1.30]	-1.493	0.8592	1.20 [0.50 - 2.37]	0.2621	2.466	0.0325*
Δ Lean weight (kg)	-0.25 [-1.12 - 1.12]	-1.133	1.35	-0.9 [-1.70 - (-0.15)]	-2.066	1.895	0.2683
Δ BMR (Kcal)	-6 [-47.00 - 49.25]	-83.98	55.65	-29.00 [-52.00 - (-4.00)]	-50.3	-1.269	0.2367
Δ Water (%)	-0.1500 [-1.75 - 0.0]	-8.648	2.515	0.05 [-0.62 - 0.62]	-0.4368	0.3653	0.1219
Δ Total water (L)	-0.2 [-0.67 - 1.45]	-2.947	7.463	-1.05 [-1.70 - (-0.37)]	-1.768	-0.1467	0.0371*
Δ WC (cm)	1.50 [-1.00 - 2.00]	-1.254	3.587	1.50 [-1.00 - 3.00]	-0.1894	2.761	0.9253

*BIA: bioimpedance; WC: waist circumference; Δ: amplitude; CI: confidence interval; LL: lower limit; UL: upper limit; BMR: basal metabolic rate; * significant difference between study end and baseline. Statistical tests: nonpaired Student t test or Mann Whitney test according to data normality.*

of body fat percentage between groups was considered high ($d = 0.96$), as was the effect size of fat weight ($d = 0.89$). The effect size of lean weight was small ($d = 0.06$).

Food frequency

Regarding food frequency, the paired analysis showed no significant difference in most food groups ($p > 0.05$), but a significant increase in the intake of sweets and desserts was observed in the CRG ($p = 0.0425$), while the VRG showed a significant increase in the intake of vegetables ($p = 0.0455$), sauces and seasonings ($p = 0.0245$). Table 4 compares the food frequency variation between the two groups, showing a significantly higher intake of vegetables, sauces and seasonings in the VRG as compared to that of the CRG. No significant difference was observed in the consumption of other food groups.

Functional capacity and blood glucose level

Figure 2 shows the functional capacity values of the individuals assessed. The distance covered increased significantly in both groups after undergoing the training protocols.

Figure 3 depicts the blood glucose levels during the training sessions and the significant differences found,

Table 4 - Comparison of the variations in monthly food frequency between the conventional and virtual reality rehabilitation groups (CRG and VRG, respectively) expressed as median and interquartile range (25%-75%)

FFQ (monthly)	CRG	95% CI LL	95% CI UL	VRG	95% CI LL	95% CI UL	p value
Δ Soups and pasta	-0.03 [-0.62 - 0.39]	1.086	2.679	0.47 [-0.61 - 1.00]	-0.3105	1.046	0.4253
Δ Meat and fish	5.69 [3.00 - 6.74]	3.793	6.639	-0.03 [-1.31- 1.48]	-1.616	3.148	0.959
Δ Milk and dairy products	-1.25 [-5.48 - 3.34]	-4.758	4.462	1.52 [-0.46 - 4.16]	-1.413	8.867	0.1052
Δ Pulses and eggs	0.61 [-0.01 - 2.05]	-0.8971	5.359	-0.62 [-6.67 - 1.37]	-4.76	1.79	0.0896
Δ Rice and tubers	0.35 [-2.50 - 3.75]	-1.465	2.93	1.32 [-0.25 - 4.49]	-0.4805	3.702	0.5351
Δ Vegetables	-1.14 [-7.37 - 1.96]	-5.797	0.9937	4.13 [-1.30 - 7.60]	0.1081	9.09	0.0147*
Δ Sauces and seasonings	-2.62 [-10.53 - 3.87]	-9.435	6.022	8.84 [-2.60 - 21.25]	2.479	17.8	0.0269*
Δ Fruits	2.35 [-0.20 - 6.09]	-1.871	5.892	1.25 [-1.49 - 5.56]	-0.6194	6.075	0.7617
Δ Beverages	0.44 [-3.66 - 3.40]	-8.269	17.58	-0.21 [-6.79 - 5.46]	-6.769	3.609	0.7381
Δ Breads and cookies	1.24 [-3.39 - 10.04]	-2.224	10.33	-0.69 [-4.19 - 3.69]	-4.104	6.035	0.3413
Δ Sweets and desserts	5.12 [0.26 - 7.68]	-1.185	7.903	2.50 [-0.90 - 8.75]	-0.3229	8.867	0.9181

*FFQ: food frequency questionnaire; Δ: amplitude; CI: confidence interval; LL: lower limit; UL: upper limit; * significant difference between study end and baseline. Statistical tests: nonpaired Student t test or Mann Whitney test according to data normality.*

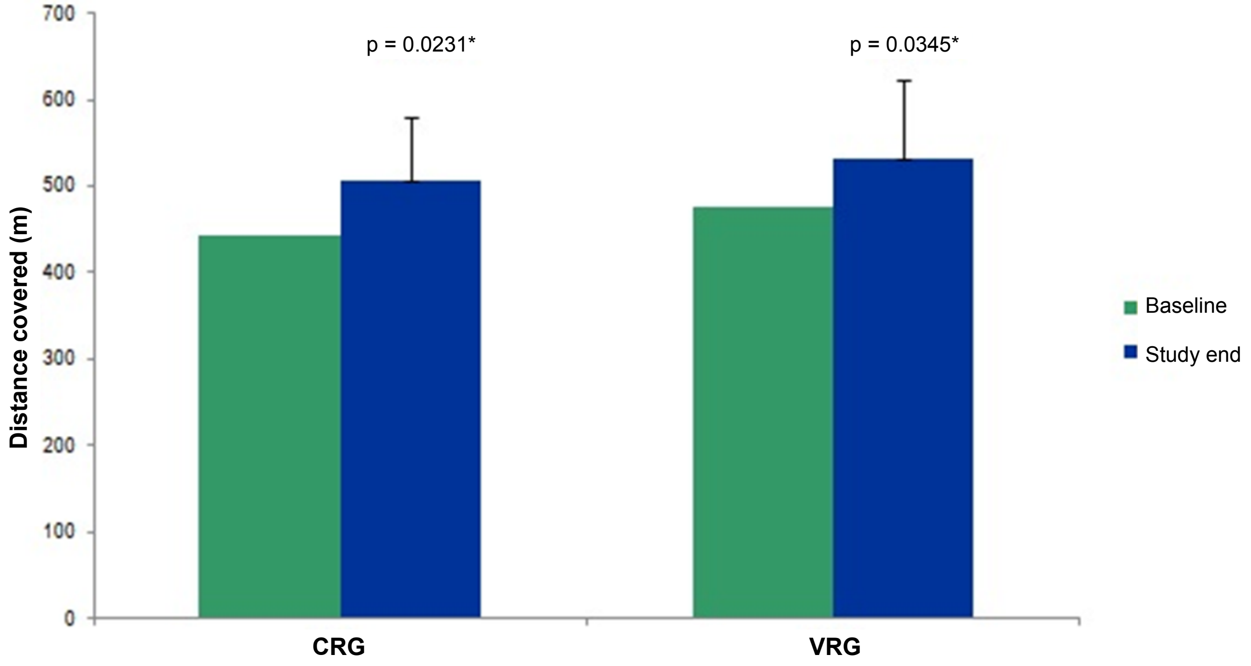

Figure 2 - Functional capacity (mean, standard deviation) of the conventional and virtual reality rehabilitation groups (CRG and VRG, respectively) at baseline and study end. *significant difference between study end and baseline.
CRG: conventional rehabilitation group; VRG: virtual reality rehabilitation group.

with a significant decrease in capillary blood glucose levels in CRG and VRG by the end of the sessions.

Table 5 compares the variation in functional capacity and blood glucose levels in the groups, but with no significant difference.

Unwanted effects

One individual reported dyspnea and intense fatigue when undergoing the VR protocol, which interrupted the session.

Discussion

The present study showed that conventional and VR cardiovascular rehabilitation influenced functional capacity and blood glucose level positively, which did not significantly differ between the training modalities. However, no favorable change in body composition and food frequency was observed in the individuals assessed.

Structured cardiovascular rehabilitation programs can provide several benefits to individuals with CVD, such as desirable changes in body composition.[29,30] After

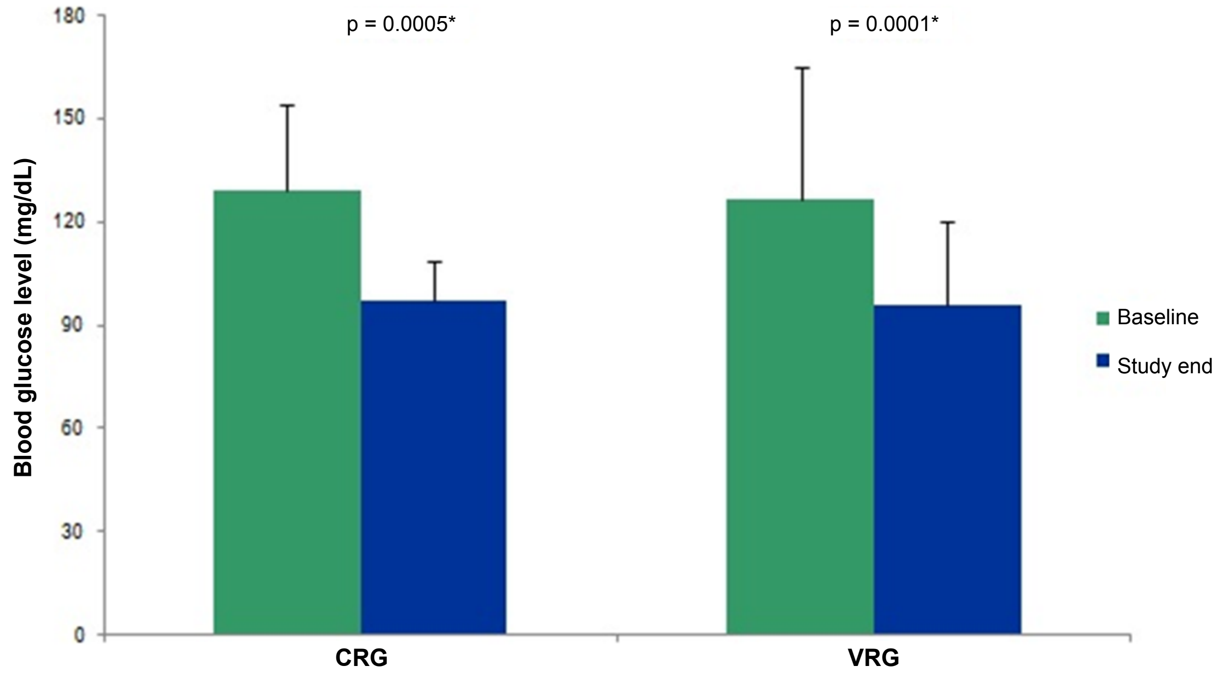

Figure 3 - Blood glucose levels (mean, standard deviation) of the conventional and virtual reality rehabilitation groups (CRG and VRG, respectively) at baseline and study end. *significant difference between study end and baseline.
CRG: conventional rehabilitation group; VRG: virtual reality rehabilitation group.

Table 5 - Comparison of the variations in functional capacity and blood glucose levels between the conventional and virtual reality rehabilitation groups (CRG and VRG, respectively) expressed as median and interquartile range (25%-75%)

6MWT/ BGL	CRG	95% CI LL	95% CI UL	VRG	95% CI LL	95% CI UL	p value
Δ Distance covered (m)	54.00 [23.43 - 71.39]	10.83	120.3	35.25 [6.875 - 93.63]	4.719	106.2	0.4253
Δ BGL (mg/dL)	-19.80 [-52.45 - (-17.74)]	-45.47	-17.66	-23.22 [-50.24 - (-12.56)]	-44.13	-18.17	0.7381

*6MWT: 6-minute walk test; BGL: blood glucose level; Δ: amplitude; CI: confidence interval; LL: lower limit; UL: upper limit; * significant difference between study end and baseline. Statistical test: Mann Whitney test according to data normality.*

undergoing the training protocol, unexpected higher fat mass gain was observed in the VRG as compared to the CRG. Ades et al.,[31] have reported that, of the behavioral changes for weight control, the following are worth noting: self-monitoring with systematic observation and recording of dietary habits; environmental change associated with eating and exercising to control stimuli; and strategies to control factors that can lead to excessive caloric ingestion.

The use of technologies that allow man-machine interaction in a real three-dimensional environment as a modality of treatment is increasing.[32] However, there is no substantial evidence of change in body composition by use of exergames as an alternative to other intervention types.

The methods used in this study included behavioral changes for weight control. However, the duration of the intervention might have influenced the results, and an intervention longer than eight weeks might benefit body composition.

Cardiovascular rehabilitation programs are usually 12-week long or shorter, and, changes in lifestyle, such as weight loss, require a longer period, such as 16 to 24 weeks. Thus, positive changes in body composition in a rehabilitation program might require a longer follow-up time. In addition, no nutritional guidance was provided. All those factors associated might explain the negative effects regarding body composition. Brennan B[33] has reported that a combined aerobic and resistance training is more effective than aerobic training alone to improve body composition in individuals with coronary artery disease.

Total body water is known to reduce as body fat increases; thus, a more metabolically active muscle tissue needs more water to perform the cellular exchange of metabolites and nutrients.[34] Thus, one can infer that the greater the amount of muscle and the lower the amount of adipose tissue, the higher the total body water proportion. This reflects on the decrease of total water in the VRG, which had an increase in fat percentage. However, the opposite can happen: the hydration level can change resistance and lean and fat weight, influencing the results.

Lima et al.,[35] have compared the effects of combined aerobic and resistance training with those of aerobic training alone on blood pressure and body composition of 44 hypertensive individuals, performing three training sessions per week for ten consecutive weeks. Regarding body composition, fat mass was reduced only in the combined aerobic and resistance training group, corroborating the findings of the present study, in which the CRG (aerobic and resistance exercises) showed a decrease in fat mass, although with no statistical significance.

This study showed inconsistent results regarding the food intake of individuals with CVD. The paired analysis showed an increase in the intake of sweets and desserts in a group without any significant change in body composition, while the group with an increase in the body fat percentage and fat weight showed a significant increase in the intake of vegetables, sauces and seasonings. These findings can be related to particularities of the FFQ used in the present study.

Slater et al.,[36] have reported sources of errors related to the FFQ due to the restrictions imposed by a defined list of food, dependence on recollection, food portion perception and the way the questions are interpreted. Thus, the FFQ proved to be a subjective tool of food frequency analysis, emphasizing the lack of nutritional guidance during the treatment protocol.

Despite the limitations of the questionnaires that assess food frequency and dietary habits, such parameters should be assessed, because inadequate dietary intake can be one of the major determinants of the increase in deaths from CVD in Brazil.[37]

Regarding the distance covered in the 6MWT,[25] significant improvement was observed in both groups, but, when compared, the gains did not differ. Klompstra et al.,[38] have reported similar results when adopting VR, by use of Nintendo Wii, at the home of individuals with heart failure for 12 weeks, with a significant improvement in the 6MWT.

In addition, a systematic review has evidenced the susceptibility of the 6MWT to changes in the clinical status after cardiac rehabilitation.[39] Thus, the improvement in functional capacity is believed to relate to the increase in the maximal consumption of oxygen in individuals with CVD, which results from training-induced adaptations, specifically the aerobic component, which leads to an increase in cardiac output, maximum systolic volume, tolerance to muscle acidosis, and elevation in the anaerobic threshold that characterize improvement of the tolerance to submaximal exercise.[40]

Regarding blood glucose levels, both groups showed a significant reduction after the sessions, but with no difference between them. Kempf et al.,[41] have reported that the use of exergames reduced blood glucose levels in individuals with type 2 diabetes mellitus who exercised with Nintendo Wii® (*Wii Fit Plus)* for 30 minutes for 12 weeks.

That finding results from the fact that the intervention proposed is the physical exercise practice, which increases muscle capillarization, improves mitochondrial function and, via an insulin-independent mechanism, involves the muscle glucose transporter (GLUT 4), improving insulin resistance and decreasing blood glucose levels.[42]

This study evidenced similar gain potentials in certain variables for both training modalities, showing VR as a complementary and innovative tool that contributes in a motivational, interactive and functional manner. Thus, the use of technologies as an intervention can be added to cardiovascular rehabilitation programs.

This study has limitations, such as its reduced sample size and intervention duration, requiring further investigation to confirm its findings. In addition, there was no nutritional guidance, which might have influenced the results regarding body composition.

Conclusion

Both groups showed a positive effect of conventional and VR cardiovascular rehabilitation on functional capacity and blood glucose levels, but with no difference between them. However, neither body composition nor food frequency improved after the interventions.

Author contributions

Conception and design of the research: Silva JPLN, Novaes LFM, Santos LCR, Galindo BP, Cavalcante MA, Araújo BCG, Pacagnell FL, Freire APCF. Acquisition of data: Silva JPLN, Novaes LFM, Santos LCR, Galindo BP, Cavalcante MA, Pacagnell FL, Freire APCF. Analysis and interpretation of the data: Silva JPLN, Novaes LFM, Santos LCR, Galindo BP, Araújo BCG, Pacagnell FL, Freire APCF. Statistical analysis: Freire APCF. Obtaining financing: Cavalcante MA. Writing of the manuscript: Silva JPLN, Novaes LFM, Santos LCR, Galindo BP, Araújo BCG, Pacagnell FL, Freire APCF. Critical revision of the manuscript for intellectual content: Silva JPLN, Novaes LFM, Santos LCR, Galindo BP, Cavalcante MA, Araújo BCG, Pacagnell FL, Freire APCF.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any thesis or dissertation work.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Unoeste under the protocol number 6243.7816.4.0000.5515. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

References

1. World Health Organization. (WHO). Media Centre. The top 10 causes of death. Washington;2014.
2. Brasil. Ministério da Saúde. Secretaria de Vigilância à Saúde. Plano de ações estratégicas para o enfrentamento das doenças crônicas não transmissíveis no Brasil, 2011-2022. Brasilia; 2011.
3. Mansur AP, Favarato D. Mortalidade por doenças cardiovasculares no Brasil e na região metropolitana de São Paulo: atualização 2011. Arq Bras Cardiol. 2012;99(2):755-61.
4. Silva AKF, Barbosa MPCR, Bernardo AFB, Vanderlei FM, Pacagnelli FL, Vanderlei LCM. Cardiac risk stratification in cardiac rehabilitation programs: a review of protocols. Rev Bras Cir Cardiovasc. 2014;29(2):255-6.
5. Meirelles LR, Pinto VM, Medeiros AS, Berry JRS, Magalhães CK. Efeito da Atividade Física Supervisionada após seis Meses de Reabilitação Cardíaca: experiência inicial. Rev SOCERJ. 2006;19(6):474-81.
6. Milani M, Kozuki RT, Crescêncio JC, Pada V, Santos MDB, Bertini CQ,et al. Efeito do treinamento físico aeróbico em coronariopatas submetidos a um programa de reabilitação cardiovascular. Medicina (Ribeirão Preto. Online). 2007;40(3):403-11.
7. Cameirão MS, Badia SB, Oller ED, Verschure PF. Neurorehabilitation using the virtual reality based Rehabilitation Gaming System: methodology, design, psychometrics, usability and validation. J Neuroeng Rehabil. 2010;7(48):1-14.
8. Shih CH, Shih CT, Chu CL. Assisting people with multiple disabilities actively correct abnormal standing posture with a Nintendo Wii balance board through controlling environmental stimulation. Res Dev Disabil. 2010;31(4):936-42.
9. Cacau LAP, Oliveira GU, Maynard LG, Araújo Filho AA, Silva Junior WM, Cerqueria Neto ML,et al The use of the virtual reality as intervention

tool in the postoperative of cardiac surgery. Rev Bras Cir Cardiovasc. 2013;28(2):281-9.

10. Lieberman DA, Chamberlin B, Medina Junior E, Franklin BA, Sanner BM, Vafiadis DK; Power of Play: Innovations in Getting Active Summit Planning Committee. The power of play: Innovations in Getting Active Summit 2011: a science panel proceedings report from the American Heart Association. Circulation. 2011;123(21):2507-16.
11. Tori, R, Kirner C, Siscoutto R. Fundamentos e tecnologia de realidade virtual e aumentada. Belém (PA):Sociedade Brasileira de Computação; 2006.
12. Neves LE, Cerávolo MP, Silva E, De Freitas WZ, Da Silva FF, Higino WP, Carvalho WRG, De Souza RA. Cardiovascular effects of Zumba(®) performed in a virtual environment using XBOX Kinect. J PhysTher Sci. 2015;27(9):2863-5.
13. Garn AC, Baker BL, Beasley EK, Solmon MA. What are the benefits of a commercial exergaming platform for college students? Examining physical activity, enjoyment, and future intentions. J Phys Act Health. 2012;9(2):311–8.
14. Sousa, F.H. Uma revisão bibliográfica sobre a utilização do Nintendo® Wii como instrumento terapêutico e seus fatores de risco. Rev Espaço Acadêmico. 2011;11(123):155-160.
15. Thompson PD, Buchner D, Pina IL, Balady GJ, Williams MA, Marcus BH, Berra K, Blair SN, Costa F, Franklin B, Fletcher GF, Gordon NF, Pate RR, Rodriguez BJ, Yancey AK, Wenger NK. Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease. Circulation. 2003;107(24):3109-16.
16. Mandic S, Hodge C, Stevens E, Walker R, Nye ER, Body D, et al. Effects of Community-Based Cardiac Rehabilitation on Body Composition and Physical Function in Individuals with Stable Coronary Artery Disease: 1.6-Year Followup. Biomed Res Int. 2013: ID 903604.
17. Calegari L, Barroso BF, Bratz J, Romano S, Figueiredo GF, Ceccon M, Pimentel GL, Reolão JBC. Efeitos do treinamento aeróbico e do fortalecimento em pacientes com insuficiência cardíaca. Rev Bras Med Esporte. 2017;23(2):123-7.
18. Pimenta NM, Santa-Clara H, Sardinha LB, Fernhall B. Body fat responses to a 1-year combined exercise training program in male coronary artery disease patients. Obesity. 2013;21(4):723-30.
19. Martins J, Sousa LM, Oliveira AS. Recomendações do enunciado CONSORT para o relato de estudos clínicos controlados e randomizados. Medicina. 2009;42(1):9–21.
20. Kirinus G, Lins JB, Santos NRM. Os benefícios do exercício físico na hipertensão arterial. RBPFEX – Revista Brasileira De Prescrição E Fisiologia Do Exercício. 2009; 3(13):33-44.
21. Britto EP, Mesquita ET. Bioimpedância elétrica aplicada à insuficiência cardíaca. Rev SOCERJ. 2008;21(3):178-83.
22. Cômodo ARO, Dias ACF, Tomaz BA, Silva-Filho AA, Werustsky CA, Ribas DF, et al. Utilização da bioimpedância para avaliação da massa corpórea. Projeto Diretrizes. São Paulo: Associação Médica Brasileira; 2009.
23. Vidigal FC, Rosado LEFPL, Rosado GP, Ribeiro RCL, Franceschini SCC. Relationship between waist circumference and sagittal abdominal diameter measured at different anatomical sites and inflammatory biomarkers in apparently health men. Nutr. Hosp. 2014; 30(3): 663-670.
24. Carvalho RRS, Chagas LR. Consumo Alimentar em diabéticos atendidos na Estratégia Saúde da Família em município do Piaui. Revista Interdisciplinar. 2016;9(2):97-106.
25. Brooks D, Solway S, Gibbons WJ. ATS statement: guidelines for the six-minute walk test. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. Am J Respir Crit Care Med. 2002;166(1):111–7.
26. Malachias M V, Souza WK, Plavnik FL, Rodrigues CII, Brand~~ao AA, Neves MF, et al; Sociedade Brasileira de Cardiologia. VII Diretriz Brasileira de Hipertensão Arterial. Arq Bras Cardiol. 2016;107;3(supl 3):2-82.
27. Herdy y, Lopez-Jimenez F, Terzik CP, Milani M, Stein R, Carvalho T, et al.; Sociedade Brasileira de Cardiologia. Diretriz sul-americana de prevenção e reabilitação cardiovascular. Arq Bras Cardiol. 2014;103(2 supl 1):1-27.
28. Karvonen M, Kentala E, Mustala O. The Effects of training on heart rate. Ann Med Exp Biol Fenn. 1957;35(33):307-15.
29. Giannuzzi P, Saner H, Bjornstad H, Fioretti P, Mendes M, Cohen-Solal A, Dugmore L, Hambrecht R, Hellemans I, McGee H, Perk J, Vanhees L, Veress G. Secondary prevention through cardiac rehabilitation: position paper of the Working Group on Cardiac Rehabilitation and Exercise Physiology of the European Society of Cardiology. Eur Heart J. 2003;24(13):1273-8.
30. Piepoli MF, Corrà U, Benzer W, Bjarnason-Wehrens B, Dendale P, Gaita D, McGee H, Mendes M, Niebauer J, Zwisler AO, Schmid J. Secondary prevention through cardiac rehabilitation: from knowledge to implementation. A position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. Eur J Cardiovasc Prev Rehabil. 2010;17(1):1-17.
31. Ades PA, Savage PD, Harvey-Berino J. The treatment of obesity in cardiac rehabilitation. J Cardiopulm Rehabil Prev. 2010;30(5):289-98.
32. Klompstra LV, Jaarsma T, Strömberg A. Exergaming in older adults: a scoping review and implementation potential for patients with heart failure. Eur J Cardiovasc Nurs. 2014;13(5):388-98.
33. Brennan B. Combined resistance and aerobic training is more effective than aerobic training alone in people with coronary artery disease. Journal of Physiotherapy. 2012; 58(2), 129.
34. López Frías, Magdalena, Gómez Martínez, Mar, Ramírez López Frías, Mercedes, Teresa Galván, Carlos De, Díaz Castro, Javier, & Nestares, Teresa. Beneficio del seguimiento de un programa de rehabilitación cardíaca sobre algunos parámetros de la composición corporal. Nutrición Hospitalaria. 2014; 30(6), 1366-1374.
35. Lima LG, Bonardi JTM, Campos GO, Bertani RF, Scher LML, Moriguti JC, Ferriolli E, Lima NKC. Combined aerobic and resistance training: are there additional benefits for older hypertensive adults? Clinics. 2017;72(6):363-9.
36. Slater B, Philippi ST, Marchioni DM, Fisberg RM. Validação de Questionários de Freqüência Alimentar-QFA: considerações metodológicas. Rev Bras Epidemiol. 2003;6(3):200-8.
37. Andrade KA, Toledo MTT, Lopes MS, Carmo GES, Lopes ACS. Aconselhamento sobre modos saudáveis de vida na Atenção Primária e práticas alimentares dos usuários. Rev Esc Enf USP. 2012:46(5): 1117-24.
38. Klompstra L, Jaarsma T, Strömberg A. Exergaming to increase the exercise capacity and daily physical activity in heart failure patients: a pilot study. BMC Geriatr. 2014;14(1):119.
39. Bellet RN, Adams L, Morris NR. The 6-minute walk test in outpatient cardiac rehabilitation: validity, reliability and responsiveness--a systematic review. Physiotherapy. 2012;98(4):277-86.
40. Sociedade Brasileira de Cardiologia. Diretriz de Reabilitação Cardíaca. Arq Bras Cardiol.2005;84(5):431-40.
41. Kempf K, Martin S. Autonomous exercise game use improves metabolic control and quality of life in type 2 diabetes patients - a randomized controlled trial. BMC Endocr Disord. 2013;13(1):57.
42. American Diabetes Association. Executive summary: Standards of medical care in diabetes – 2014. Diabetes Care. 2014;37(1):S5-S13.