


Cardiopulmonary responses of the sit-to-stand test in individuals pre and post-heart surgery: cross section

Respostas cardiorrespiratórias do teste de sentar e levantar em indivíduos pré e pós-cirurgia cardíaca: corte transversal

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ABSTRACT | INTRODUCTION: The cardiorespiratory repercussions of heart surgery can be assessed through submaximal testing. **OBJECTIVE:** Compare cardiorespiratory responses to the one-minute sit-and-stand test in individuals pre- and post-heart surgery. **METHODS:** An analytical, cross-sectional study was conducted involving 45 hemodynamically stable male and female patients with an ejection fraction greater than 45% submitted to coronary artery bypass surgery at a cardiology service of a hospital in the interior of the state of REDACTED between 2018 and 2019. The following variables were collected at rest and the end of the test one day before surgery and postoperatively: systolic and diastolic blood pressure (SBP and DBP, mmHg), heart rate (HR, bpm), respiratory rate (RR, rpm), peripheral saturation oxygen (SpO₂, %), lower limb fatigue (LLF, 0-10), dyspnea (0-10), number of test repetitions and number of interruptions. The R program was used to process the data. The Shapiro-Wilk test was used for the determination of normality. The groups were compared using the non-parametric Wilcoxon test. **RESULTS:** Most participants were male (71%), and the mean age was 61±9 years. In the preoperative period, statistically significant increases ($p \leq 0.05$) were found for SBP, HR, RR, LLF, and dyspnea between resting values and the end of the test. Significant increases ($p \leq 0.05$) were found in the postoperative period for HR, RR, LLF, and dyspnea between rest and the end of the test, with no increase in SBP. Comparing the preoperative and postoperative evaluations variables, higher HR, RR, the number of interruptions and lower SBP, SpO₂, and the number of repetitions were found after surgery ($p \leq 0.05$). **CONCLUSION:** The one-minute sit-to-stand test induced physiological cardiorespiratory responses in the preoperative evaluation. However, higher cardiorespiratory responses at rest and an attenuated response to exercise were found in the postoperative evaluation compared to the preoperative evaluation.

KEYWORDS: Physiotherapy. Cardiovascular Rehabilitation. Cardiovascular disease. Physiology. Hemodynamics. One-minute sit-to-stand test.

RESUMO | INTRODUÇÃO: As repercussões cardiorrespiratórias da cirurgia cardíaca podem ser avaliadas por teste submáximo. **OBJETIVO:** comparar as respostas cardiorrespiratórias do teste de sentar e levantar em um minuto (TSL1) nos indivíduos, entre o momento pré e pós de cirurgia cardíaca. **MÉTODOS:** Estudo de caráter transversal e analítico, incluiu 45 indivíduos de ambos os sexos, estáveis hemodinamicamente, com fração de ejeção maior que 45%, que foram submetidos à cirurgia de revascularização do miocárdio no Instituto do Coração de um Hospital do interior do estado do Rio Grande do Sul, entre 2018 e 2019. As variáveis de desfechos foram coletadas no repouso e ao final do teste, um dia antes da cirurgia e no pós-operatório: pressão arterial sistólica e diastólica (PAS e PAD em mmHg), frequência cardíaca (FC bpm), frequência respiratória (FR rpm), saturação periférica de oxigênio (SpO₂ %), fadiga de membros inferiores (Fmm 0-10) e dispneia (Di 0-10), número de repetições e interrupções do teste. Foi utilizado o programa R para o tratamento dos dados, para avaliar a normalidade foi aplicado o teste de Shapiro Wilk, a comparação dos grupos pelo teste não paramétrico de Wilcoxon. **RESULTADOS:** A maioria do sexo masculino (71%) e média de idade foi de 61±9 anos. No pré-operatório, ocorreu aumento entre o repouso e o final do teste, PAS, FC, FR, Fmm e Di ($p < 0,05$). No pós-operatório, houve aumento entre o repouso e o final do teste, para FC, FR, Fmm e Di ($P < 0,05$), contudo, sem elevação da PAS. Ao comparar as variáveis entre os momentos pré e pós, observamos maiores valores da FC, FR e número de interrupções na condição pós ($p < 0,05$), bem como menores valores para a PAS, SpO₂ e número de repetições ($p < 0,05$) para essa condição. **CONCLUSÃO:** Os dados desta pesquisa comprovam que o TSL1 realizado no pré-operatório de cirurgia cardíaca, assim como entre o 4° ou 5° dia de pós-cirurgia cardíaca, é seguro e eficaz, representado pela ausência das repercussões cardiorrespiratórias que comprometessem ou agravassem o quadro clínico do paciente. O TSL1 foi capaz de induzir respostas cardiorrespiratórias fisiológicas no pré-operatório; contudo, na condição pós acarretou respostas cardiorrespiratórias mais elevadas no repouso e atenuada resposta em exercício em comparação ao pré-operatório.

PALAVRAS-CHAVE: Fisioterapia. Reabilitação Cardiovascular. Doenças cardiovasculares. Fisiologia. Hemodinâmica. Teste sentar e levantar em um minuto.

Introduction

Cardiovascular disease is the most common cause of morbidity and mortality in the world.¹ Therapeutic, clinical and surgical advances have contributed to the prevention of acute events, the relief of symptoms and improvements in both the prognosis and quality of life. Heart surgery is highly complex and requires intensive care² as well as interdisciplinary care. Moreover, physiotherapeutic rehabilitation is essential in the postoperative period.³

The sit-to-stand test is one of the most widely used methods for the in-hospital physiotherapeutic evaluation of patients submitted to heart surgery.⁴ This test is used to assess physical capacity and peripheral muscle endurance (lower limbs).⁵ Other advantages include the short administration time and the fact that it can be performed practically anywhere.⁶ It is considered a safe test with low cardiovascular risk that can be used in clinical practice.⁷

Vital signs are classic measures of hemodynamics and well established in the literature as important diagnostic tools.⁸⁻¹¹ Pinsky et al. report the importance of functional monitoring for the dynamic evaluation of hemodynamic variables in response to a predefined disturbance.¹⁰ According to García et al.¹¹, it is reasonable to presume some degree of hypovolemia in the occurrence of cardiovascular insufficiency, which is characterized by poor tissue perfusion when the heart rate (HR) increases and/or blood pressure (BP) diminishes when sitting down or standing up. In this situation, the evaluative measures do not change, but there is an alteration in the values obtained in response to the predefined physiological challenge.

The sit-to-stand test is a submaximal test involving the determination of the number of repetitions of the act of standing up and sitting down on a chair without the assistance of the upper limbs and the number of

interruptions of the test a patient requires. This test is used in different populations, such as individuals submitted to heart surgery¹², those with chronic kidney disease¹³, older people⁷, smokers¹⁴ and healthy individuals.¹⁵ Hemodynamic and respiratory responses can also be measured during the test, as vital signs can be collected at rest prior to the test as well as at the end of the exercise.^{7,15} The test can be executed in 30 seconds^{7,15} or one minute.^{4-6,12,13} The one-minute sit-to-stand test (SST1) was selected for the present study due to the greater scientific evidence reported in the literature with this duration and the fact that this is the routine modality used at the teaching institution where the study was conducted.

Heart surgery leads to changes in hemodynamic and respiratory responses, which can impact the results of functional tests, as described in the literature.^{7,15} However, this is a need for studies involving different populations as well as the identification of the age group most affected by the repercussions of surgery, considering the epidemiological transition related to the aging of the population, transformations brought about by urbanization, and globalization as well as the lifestyle of individuals.¹⁶ The present study is relevant because it analyzes the hemodynamic and respiratory repercussions of surgery through a low-cost test to assess functional physical capacity, which can be applied in clinical practice. Another aspect is that we did not identify scientific evidence that would describe this analysis comparing the hemodynamic and respiratory responses between the different surgical moments, that is, between the pre-and postoperative periods of cardiac surgery. Moreover, a literature search revealed no previous studies comparing hemodynamic and respiratory responses between preoperative and postoperative evaluations of patients submitted to heart surgery.

As knowledge of these responses in different periods related to surgery is fundamental to guiding the

conduct of physiotherapists thus, the objective compared the cardiorespiratory responses of TSL1 in individuals between the time before and after cardiac surgery.

Methods

The present analytical, cross-sectional study received approval from the institutional review board of Universidade Regional do Noroeste do Estado do Rio Grande do Sul (process number: 38912120.1.0000.5350; certificatenumber:4.400.333). Data collection occurred between 2018 and 2019. The sample was composed of 45 hemodynamically stable male, and female individuals with an ejection fraction greater than 45% submitted to heart surgery at the cardiology service of a hospital in the state of Rio Grande do Sul, Brazil, who agreed to participate in the study by signing a statement of informed consent. Individuals with orthopedic or neurological problems, those with complications that surpassed six days, and those that did not complete the protocol at the two evaluation times were excluded from the study.

The following data were collected from patient charts to characterize the sample: age, sex, diabetes mellitus, history of acute myocardial infarction, systemic arterial hypertension, dyslipidemia, chronic obstructive pulmonary disease (COPD), and anthropometric measures (weight and height). In addition, the following in-hospital variables related to surgery were also collected: clamping of the aorta (minutes), duration of extracorporeal circulation (minutes), left ventricle ejection fraction (percentage), duration of surgery (minutes), stay in an intensive care unit (hours), stay inward (hours) and total hospital stay (hours).

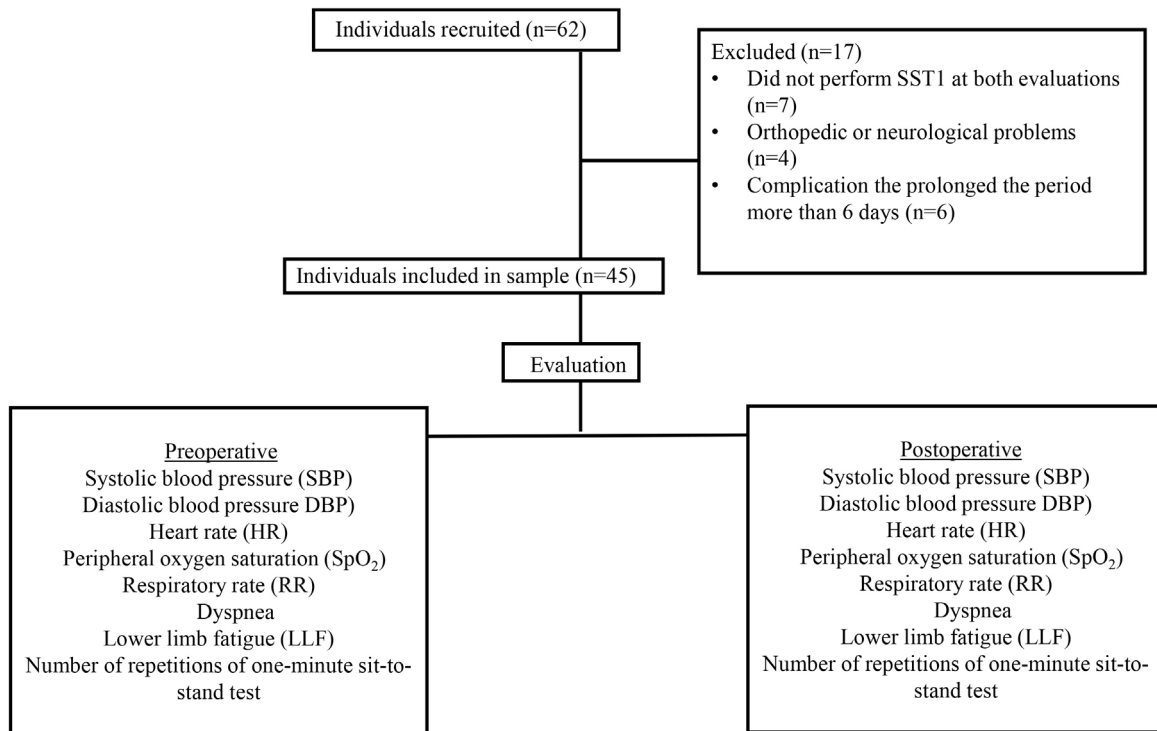
The SST1 was adapted as described in the study by Ozalevli et al.⁵: at the physiotherapist's cue, the individual stood up and sat down again on a chair without the assistance of the upper limbs and repeated the task as fast as safely possible the maximum number of times within one minute. The test was performed one day before surgery and postoperatively before discharge from the hospital (fourth or fifth day after surgery). The following hemodynamic and vital respiratory signs were collected at rest prior to the test and at the end of the test: systolic blood pressure (SBP in mmHg), diastolic blood pressure (DBP in mmHg), heart rate (HR, bpm), respiratory rate (RR, rpm), peripheral oxygen saturation (SpO₂), the sensation of lower limb fatigue (LLF, 0-10), dyspnea (0-10), number of repetitions and number of interruptions.

The R program (version 4.0.3) was used for the statistical analysis. The data were expressed as absolute and relative frequencies. Quantitative variables were expressed as mean and standard deviation. No categorization was employed or median, first and the third quartile being applied. The Shapiro-Wilk test was used for the determination of normality. The groups were compared using the non-parametric Wilcoxon test to determine significant differences in the variables, $p < 0,05$.

Results

Sixty-two individuals were recruited, 17 of whom were excluded. Thus, the final sample was composed of 45 individuals (Figure 1).

Figure 1. Flowchart of study



SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; SpO₂: peripheral oxygen saturation; RR: respiratory rate; LLF: lower limb fatigue

Most participants were men (71%). The mean age was 61 ± 9 years. Regarding risk factors, the frequency of overweight was 84% (n = 34). The mean duration of surgery was 199 ± 48 minutes, duration of clamping of the aorta was 61 ± 15 minutes, ECC was 73 ± 17 minutes, and total hospital stay was 7 ± 1 days (Table 1).

Table 1. Characterization of sample, clinical and in-hospital variables of patients submitted to elective heart surgery

	Men	Women	Total
Sample size, n (%)	32 (71)	13 (29)	45 (100)
Age, mean ± SD	61 ±9	62 ±9	61 ±9
Risk factors, n(%)			
Diabetes	17 (38)	7 (16)	24 (53)
Dyslipidemia	8 (18)	2 (4)	10 (22)
COPD	4 (9)	1 (2)	5 (11)
AMI	13 (29)	4 (9)	17 (38)
CHF	4 (9)	2 (4)	6 (13)
Overweight	28 (62)	10 (22)	38 (84)
Hypertension	21 (47)	11 (24)	32 (71)
In-hospital variables, mean ± SD			
Aorta clamp, min	61 ±13	60 ±20	61 ±15
ECC, min	74 ±16	68 ±20	73 ±17
Ejection fraction, %	64 ±12	67 ±10	64 ±12
Stay in ICU, hours	60 ±15	56 ±12	59 ±14
Stay in ward, hours	78 ±25	76 ±14	78 ±22
Total hospital stay, hours	176 ±73	152 ±28	169 ±64
Duration of surgery, min	207 ±51	177 ±34	199 ±48

SD: standard deviation; COPD: chronic obstructive heart disease; AMI: acute myocardial infarction; CHF: chronic heart failure; ECC: extracorporeal circulation; ICU: intensive care unit.

Table 2 displays the results of the SST1. In the preoperative evaluation, statically significant increases were found regarding the following variables between rest and the end of the test: SBP, HR, RR, LLF, and dyspnea ($p < 0.05$). Significant increases were also found during the postoperative evaluation for these same variables ($p < 0.05$), except for SBP. No changes in DBP or SpO₂ were found during either the preoperative or postoperative evaluations. A significant reduction was found in the number of repetitions between the preoperative (18 repetitions) and postoperative (10 repetitions) evaluations ($p \leq 0.001$). In the comparison of evaluation times for the resting phase and end of the SST1, higher HR and RR as well as lower SBP, SpO₂, and several repetitions were found postoperatively ($p < 0.05$).

Table 2. Cardiorespiratory variables before and after SST1 in preoperative and postoperative periods of patients submitted to elective heart surgery

	Preoperative N = 45		Postoperative N = 45		p-value
	Mediana e (Q1 - Q3)	p-value	Mediana e (Q1 - Q3)	p-value	
SBP - initial	130 (120 - 140)	0.0071*	120 (120 - 130)	0.127	0.0395*
SBP - final	140 (130 - 150)		130 (120 - 140)		0.0015*
DBP - initial	80 (80 - 90)	0.8040	80 (70 - 80)	0.3264	0.0580
DBP - final	80 (80 - 90)		80 (70 - 90)		0.2461
HR - initial	68 (63 - 79)	0.0006*	87 (79 - 98)	0.0209*	$\leq 0.001^*$
HR - final	83 (67 - 94)		93 (87 - 108)		0.0008*
SPO ₂ - initial	96 (95 - 97)	0.6403	94 (92 - 96)	0.4021	0.0002*
SPO ₂ - final	96 (95 - 98)		96 (92 - 97)		0.0069*
RR - initial	17 (14 - 18)	$\leq 0.001^*$	18 (15 - 21)	0.0287*	0.0126*
RR - final	19 (17 - 20)		20 (19 - 23)		0.0086*
Dyspnea - initial	0 (0 - 0)	0.0013*	0 (0 - 0)	0.0016*	0.6958
Dyspnea - final	0 (0 - 2)		0 (0 - 2)		0.7458
LLF - initial	0 (0 - 0)	0.0175*	0 (0 - 0)	0.0366*	0.9478
LLF - final	0 (0 - 1)		0 (0 - 0)		0.6591
N° of repetitions	18 (15 - 22)		10 (7 - 12)		$\leq 0.001^*$

SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; SpO₂: peripheral oxygen saturation; RR: respiratory rate; LLF: lower limb fatigue. Intragroup (before and after test) and inter-group (preoperative and postoperative) comparisons performed with Wilcoxon's test.

Discussion

The present study compared cardiorespiratory responses to the one-minute sit-to-stand test (SST1) in individuals before and after heart surgery. The main findings were the expected physiological responses to SST1, with significant increases in SBP, HR, RR, LLF, and dyspnea after the test in the preoperative evaluation and an increase in these same variables, except SBP, in the postoperative evaluation. In comparing the two evaluation times, significant increases in HR, RR, and the number of interruptions and significant reductions in SBP, SpO₂, and the number of repetitions were found during the postoperative evaluation.

The significant reduction in the number of repetitions from 18 in the preoperative test to 10 in the postoperative test agrees with data described by Steffens et al., who found a reduction in the number of repetitions of the SST1 from 17.98 (preoperative period) to 14.51 (postoperative period).¹² Other studies involving patients submitted to heart surgery report similar results, such as a reduction from 17.38 to 10.83 in the standard rehabilitation group and from 18.50 to 13.36 in the intervention rehabilitation group in the study conducted by Windmoller et al.⁴ The number of repetitions of the SST1 among patients submitted to heart surgery is much lower in both the preoperative and postoperative tests than other populations, demonstrating that these patients have poorer physical performance. Compared to the preoperative test, the significant reduction in the postoperative test can be attributed to the low exercise capacity induced by the procedure itself, which constitutes major surgery and leads to significant changes.¹⁶ Other possible causes include immobility (restricted to the bed during hospitalization) and the use of medications.

The present study revealed a reduction in peripheral muscle endurance between the preoperative and postoperative periods of heart surgery. Such changes influenced by the surgical procedure indicate the need to measure functioning before and after surgery to obtain knowledge on the dynamics of the therapeutic process and intervene when necessary to avoid the occurrence of functional limitations. Ozalevli et al. used the SST1 to evaluate peripheral muscle endurance in a population of individuals with COPD. They found that, like the Six-Minute Walk Test, the SST1 determines functional status but has the advantages of causing less hemodynamic stress and its ease and practicality for assessing the physical status of patients.⁵

Regarding the cardiorespiratory responses to the SST1 compared to the preoperative evaluation, significant increases were found regarding HR, RR, and the number of interruptions, whereas significant reductions were found regarding SBP, SpO₂, and the number of repetitions during the postoperative evaluation. These findings may be related to the stress of heart surgery, the use of medications, immobility on the hospital bed, difficulty executing gas exchanges, and pain from the surgical incision.

Gottardi et al. evaluated six healthy patients using the 30-second and one-minute SST and found increases in HR, SBP, and the Borg Scale results with both modalities, but no significant effect on SpO₂, in healthy subjects.¹⁵ Morais et al. administered the 30-second SST to two groups of older people (sedentary and active) and found significant increases in SBP (117.3 to 125.3 mmHg) and HR (75.1 to 94.8 bpm) in the sedentary group, but only significant increases in HR (73.7 to 79.6 bpm) and RR (16.4 to 18.8 rpm) in the active group.⁷ However, the SBP response to the test was discrete and well short of being considered inadequate by healthcare guidelines (SBP > 220 mmHg or DBP > 115 mmHg). This demonstrates the safety of the test, which offers low cardiovascular risk and can be used safely in clinical practice.

In the analysis of cardiorespiratory responses, significant increases occurred between the resting values and those found at the end of the SST1 in the preoperative evaluation regarding SBP, HR, RR, LLF, and dyspnea. Significant increases also occurred in these same variables in the postoperative evaluation, except for SBP. Similar findings are described in the cross-sectional study conducted by Morais et al.

involving 30 older people divided into a sedentary group and active group, with a significant increase in SBP ($p < 0.001$) and HR ($p < 0.001$) in the sedentary group, but significant increases only in RR ($p < 0.001$) and HR ($p = 0.003$) in the active group. An increase in SBP was found after the sit-to-stand test only in the sedentary group.⁷ That supports the hypothesis of positive cardiovascular adaptation, as the pressure response to the effort is attenuated by physical exercise. With time, however, the tendency is toward autonomic regulation and a reduction in this variable. The increase in these variables is physiological and found on other tests, such as the 100-meter walk test.¹⁷ Cordeiro et al. analyzed hemodynamic variables in 30 individuals submitted to heart surgery during a 100-m walk protocol, which promoted immediate responses, such a significant increase in HR (81.7 to 94.1 bpm) and RR (19.4 to 24 rpm), and found no changes in SBP, DBP or SpO₂, as the 100-m walk test is considered mild.¹⁷ In the present study, increases in HR and RR were found even on a submaximal test.

The increase in the physiological variables, except for SBP, and the reduction in repetitions are repercussions of major heart surgery.^{6,18,19} Patients submitted to such surgical procedures are debilitated in the postoperative period due to the opening of the chest, which leads to a reduction in the physical ability to perform the test. This may explain the behavior of SBP in the postoperative period, as these variable increases when there is increased exertion.^{8,18,19} Another aspect was the fact that the test did not lead to changes in DBP or SpO₂. Physical effort during exercise may not alter DBP.^{12,20,21} Moreover, the participants were heart patients but with no previous lung disease described on the patient charts, which may explain the maintenance of the values of these variables during the test.^{12,19,22,23}

The SST1 performed both prior to heart surgery and four to five days after surgery was safe in the present study, as no changes occurred that might compromise the performance or continuity of the test. No patients had to stop the test due to a hemodynamic or respiratory repercussion that might negatively impact their clinical status. The test demonstrated the loss of peripheral muscle endurance caused by the surgery, as evidenced by the reduction in the number of repetitions of the test after surgery compared to the preoperative evaluation.

The results of this test are indicative of changes resulting from heart surgery. Therefore, they can be used to prescribe physical exercise after discharge from the hospital through multidisciplinary follow-up, considering the need for physiotherapeutic rehabilitation based on the responses to the SST1.

This study offers scientific evidence of the contribution of the SST1 applied following heart surgery. However, some limitations of the study should be addressed. The investigation was conducted at a single center, and, therefore, the data cannot be extrapolated to populations with a different profile. Other limitations were the failure to determine the physical activity level of the participants and the non-identification of smokers in the sample.

Conclusion

The present findings demonstrate that the one-minute sit-to-stand test performed prior to heart surgery and four to five days postoperatively is safe and effective, as demonstrated by the absence of cardiorespiratory repercussions that might aggravate the clinical status of the patients.

Authors' contributions

Silva LG participated in the conception, design, search, and statistical analysis of research data, interpretation of results, writing the scientific article, review, and final approval. Silva MMD participated in the statistical analysis of research data, interpretation of results. Windmoller P participated in data collection and final review for article approval. Silva AB participated in the review and final approval of the article. Winkelmann ER participated in the conception, design, statistical analysis of research data, interpretation of results, writing, review, and final approval of the scientific article.

Competing interests

No financial, legal, or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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