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Heart rate assessment during maximal static expiratory pressure and Valsalva maneuver in healthy young men*

Avaliação da frequência cardíaca à medida de pressão expiratória máxima estática e à manobra de Valsalva em jovens saudáveis

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Abstract

Background: The measure of the maximal expiratory pressure (MEP) has some contraindications, as it is believed that the responses obtained in this measure are similar to the Valsalva maneuver (VM). **Objective**: The main purpose of this study was to evaluate the heart rate responses (HR) during the MEP and the VM measures in healthy young men into different postures aiming to identify whether and in which situation the MEP reproduces the responses obtained in the VM. Additionally we aim to estimate the workload realized during the maneuvers. **Method**: Twelve healthy young men were evaluated, instructed and familiarized with the maneuvers. The VM was characterized by an expiratory effort (40 mmHg) against a manometer for 15 seconds. The MEP measure has been performed according to the American Thoracic Society. Both measures were performed at sitting and supine positions. ANOVA two-way with Holm-Sidak post-hoc test ($p<0.05$) was used to analyse the heart rate variation (ΔHR); Valsalva index (VI); MEP index (MEPI), and the estimated workload of the maneuvers (W_{total}, $W_{isotime}$, $W_{total}/\Delta HR_{total}$ and $W_{isotime}/\Delta HR_{isotime}$). **Results**: The ΔHR during the maneuvers was not influenced by the supine and sitting positions. However, the ΔHR during the VM and VI were higher (supine: 47±9 bpm, 2.3±0.2; sitting: 41±10 bpm, 2.0±0.2, respectively) than ΔHR during the MEP and MEPI values (supine: 23±8 bpm, 1.5±0.2; sitting 24±8 bpm, 1.6±0.3, respectively) ($p<0.001$). The estimated workload of the maneuvers was statistically different ($p<0.001$) between the maneuvers, except to $W_{total}/\Delta HR$. **Conclusions**: In the studied conditions the MEP does not reproduces the HR response observed in the VM in healthy young men.

Keywords: Valsalva maneuver; respiratory muscle; heart rate; autonomic nervous system; posture; physical therapy.

Resumo

Contextualização: A medida de pressão expiratória máxima (PEmáx) possui algumas contraindicações, pois acredita-se que as respostas obtidas nessa medida são similares às respostas encontradas na manobra de Valsalva (MV). **Objetivos**: O objetivo principal é avaliar a resposta da frequência cardíaca (FC) durante a medida da PEmáx e da MV em jovens saudáveis, em diferentes posturas, para identificar se e em qual condição a PEmáx reproduz as respostas obtidas na MV e, adicionalmente, estimar o trabalho realizado nas manobras. **Método**: Doze jovens saudáveis foram avaliados, orientados e familiarizados com as manobras. A MV foi composta por um esforço expiratório (40 mmHg) durante 15 segundos contra um manômetro. A PEmáx foi executada segundo a *American Thoracic Society*. Ambas as medidas foram realizadas nas posturas supino e sentado. Para a análise da variação da frequência cardíaca (ΔFC), índice de Valsalva (IV), índice da PEmáx (IPEmáx) e o trabalho estimado das manobras (W_{total}, $W_{isotime}$, $W_{total}/\Delta FC_{total}$ e $W_{isotime}/\Delta FC_{isotime}$), utilizou-se ANOVA *two-way* com post-hoc de Holm-Sidak ($p<0,05$). **Resultados**: A ΔFC durante as manobras não foi influenciada pelas posturas; entretanto, durante a MV, a ΔFC e os valores do IV foram maiores (supino: 47±9 bpm, 2,3±0,2; sentado: 41±10 bpm, 2,0±0,2, respectivamente) do que a ΔFC e os valores de IPEmáx observados durante a PEmáx (supino: 23±8 bpm, 1,5±0,2; sentado 24±8 bpm, 1,6±0,3, respectivamente) ($p<0,001$). Os trabalhos estimados das manobras foram estatisticamente diferentes ($p<0,001$) entre elas, exceto para o $W_{total}/\Delta FC$. **Conclusões**: Nas condições estudadas, a PEmáx não reproduz as respostas da FC observadas durante a MV em jovens saudáveis.

Palavras-chave: manobra de Valsalva; músculos respiratórios; frequência cardíaca; sistema nervoso autonômico; postura; fisioterapia.

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Introduction

Measurements of maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) are extensively used in clinical practice of physical therapy as a parameter of indirect evaluation of respiratory muscles strength in patients with neuromuscular[1], cardiopulmonary[2,3] and/or metabolic[4] disorders. In these situations, the MIP and MEP measurements are also used as a training prescription parameter for respiratory muscles strength and endurance[5-8]. In addition, these measures are also used as a predictive parameter of success in the discontinuation of mechanical ventilation[8-10].

Despite the clinical importance of these measures, there are several absolute and relative contraindications to their use[8,11]. The reason for the contraindication of MEP measure, which is a maneuver performed from a maximal inhalation (total lung-capacity) followed by an expiratory effort against an occluded airway is related to the similarity of this measurement with the Valsalva maneuver (VM)[7,8,12]. The performance of the expiratory effort during the MEP for periods of time longer than 3 seconds may lead to cardiovascular alterations similar to those of VM, such as: decreased cardiac output[8], venous return, pulmonary circulation and coronary flow[13-15].

The VM is a test used to evaluate the role of the autonomic nervous system (ANS). The range of responses that occur during and after the performance of the VM has been widely described in the literature[14-16]. The cardiovascular responses of the VM are mediated by the ANS and vary according to the activation and/or inhibition of the sympathetic and parasympathetic systems. This dynamic pattern of autonomic activity is determined by different stimulus, such as breathing, muscular contraction, stimulation of arterial baroreceptors[17], postural changes[18-20] and it can be more easily investigated by analyzing the responses of heart rate (HR) into a clinical environment.

Although there are similarities between the performances of the MEP and the VM[7,8,12], to date there are no studies that have described the cardiovascular responses observed during the performance of MEP in different positions. Thus, it is observed that the underuse of MEP in clinical practice of physical therapy may be associated with the possible similarity between its use and the VM[7,8,12], without the real effects of the MEP on the cardiovascular responses are known. Therefore, the investigation of the HR response to the MEP in healthy young people could contribute primarily to the understanding of the safety of this procedure. Consequently, the evaluation of the expiratory muscles can be performed with less exposure of the subjects to unnecessary risks.

Therefore, the main objective of the present study was to evaluate the hypothesis that the execution of the MEP in healthy youth subjects will generate HR responses similar to those observed during the execution of the VM, independent of the subject position. Additionally, the workload to perform each maneuver was estimated in order to characterize the maneuvers and to provide support for interpretation of the results.

Method

Subjects

Twelve healthy men, aged between 20 and 29 years-old and with body mass index (BMI) between 18.5 and 29.9 kg/m^2 participated in this study. The volunteers were informed and advised regarding the procedures that they would be submitted and they signed a consent form. The study was approved by the Ethics in Research Committee of the Universidade Federal de São Carlos (UFSCar), São Carlos, SP, Brazil (protocol nº 435/2008).

The inclusion criteria were absence of diagnosed diseases, use of medications and use of illicit drugs or smoking. In addition, the participants should not present electrocardiographic alterations at rest and during the exercise clinical test. Participants who presented discomfort during the performance of the maneuvers would be considered to be excluded. However, no subject had any signs or symptoms compatible with the need to be excluded from the study.

Procedures

The clinical evaluation, the tests and the experimental procedures were performed in the afternoon, on alternate days, with an interval of 24 hours at the Cardiovascular Physical Therapy Laboratory - Nucleus of Research in Physical Exercise - Department of Physical Therapy, UFSCar (Figure 1). During the experiments, the room temperature (between 22ºC and 24ºC) and the relative humidity of air (between 40 and 60%) were observed and controlled to not interfere on the tests results. The volunteers were instructed to not drink alcoholic and/or stimulants beverages for at least 12 hours before the test; to avoid strenuous exercises and to have a period of regular sleep with good quality on the night that preceded the data collection.

Prior to the participation in the present study, the volunteers underwent to an anamnesis, which was collected information with regards to personal data, previous pathologies,

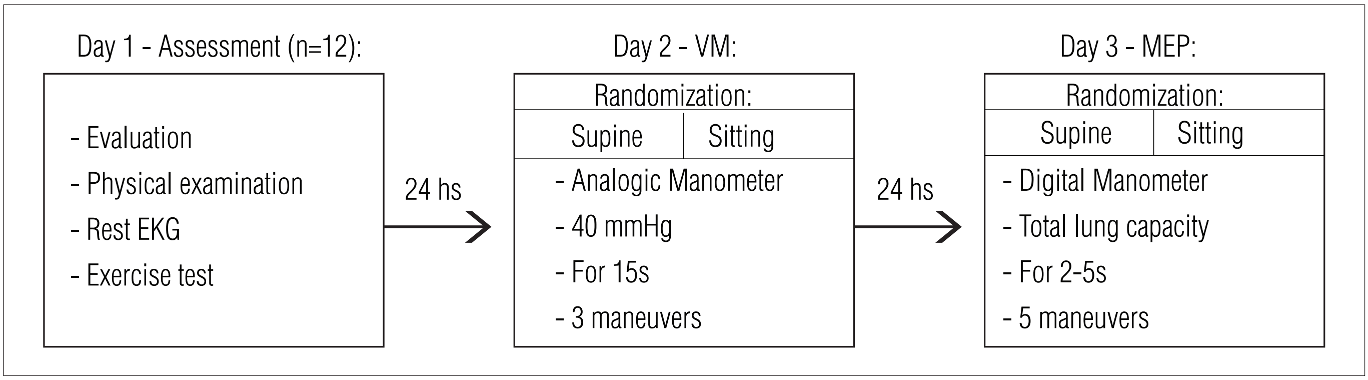

Figure 1. Description of experimental procedure.

risk factors for cardiovascular disease, smoking, medications and physical activity level. They also underwent to a physical exam to identify musculoskeletal disorders, 12-lead electrocardiogram (ECG) at resting and during test of physical exercise (Bruce protocol). In addition, familiarization procedures were performed with the equipment and experimental protocols in order to reduce the subject anxiety and expectation and to promote the learning of the VM and the MEP. The maneuvers were performed in the supine position with the volunteer positioned with the upper and lower limbs in extension and the head flexed at 45º; and in the sitting position with the volunteer positioned with the trunk leaning on the chair and the feet on the ground, making an angle of approximately 90º between the trunk and the thighs. In both positions, the volunteers were instructed to remain with their clothes pieces loosened to ensure that the respiratory movements were not limited.

Manometers

The manometers used in the present study (analogical and digital) were previously tested with regards to the measurements of the pressure values. There was no difference between the pressure values generated in the pilot study between the researchers, allowing its use. A digital manometer (MVD300, Globalmed, Brazil) connected to a microcomputer (software MVD300, Globalmed, Brazil) was used to collect the pressure values during the maneuvers and the visual control of the pressure curve *vs* time by the examiners.

Valsalva Maneuver

For the execution of VM, an analogical manometer (Dyasist, Brazil) connected to a digital manometer and a mouthpiece through a semi rigid tube was used. The volunteers should be with the nostrils occluded by a nasal clip and with the mouthpiece firmly attached to the mouth, in order to prevent the air escape. The volunteers were asked to maintain spontaneous ventilation (~15 rpm), to perform a deep inhalation before the maneuver and to execute the voluntary expiratory effort after receiving an audio signal. During the VM the volunteers should maintain the expiratory effort equivalent to 40 mmHg for 15 seconds[15,21,22]. This maneuver was repeated three times, with a minimum time interval of five minutes among them, with the aim of the HR and BP return to the baseline values. In order to guarantee the glottic opening during the performance of the maneuvers a mouthpiece with orifice was used[15]. To evaluate the correct performance of the VM, the following items were observed[16,23]: a) maintenance of pressure on the manometer; b) facial flushing; c) jugular stasis; d) movements of the chest and e) rapid increase of HR followed by bradycardia. The order that the volunteers performed the maneuvers, i.e. supine or sitting positions, was random.

Maximal Expiratory Pressure (MEP)

The MEP measures were carried out using a digital manometer and a mouthpiece with a 2 mm orifice[7,8,24]. The volunteers were instructed to take a deep breath from the residual volume to total lung capacity, to maintain the nostrils occluded by a nasal clip and the mouthpiece firmly attached to the mouth, in order to prevent the escape of air, to maintain spontaneous ventilation (~15 rpm) and to execute the expiratory effort after receiving the audio signal. Five attempts of maximal expiratory effort were performed, being at least three of them should be reproduced, that is, they could not differ to each other more than 10%. The volunteer should sustain the expiratory effort for at least two seconds. During this period, the examiner observed the curve generated by the expiratory effort on the microcomputer screen (software MVD300, Globalmed, Brazil), in order to identify the development of a plateau. The expiratory pressure value observed at the first second of the plateau after the peak pressure of each maneuver was recorded and compared with the predictive values for the Brazilian population[25]. If the highest value was observed in the last attempt, a new measure would be performed, in order to exclude the learning effect[7,8,24]. Between the measures, there was an interval of five minutes in order to reproduce the procedure used in the VM. For the MEP measures, the order of the positions was randomly defined.

RRI Capture

To capture the intervals between two R waves (RRI) a portable heart rate monitor was used (S810i, Polar, Finland). To guarantee the quality of the signal, electrocardiographic signals measured by a one-channel heart monitor (TC-500, ECAFIX, São Paulo, SP, Brazil) were observed. The electrodes were positioned on the derivation MC5, being the negative pole placed at the sternal notch (M) and the positive pole and the ground wire placed at the area of the 5th intercostal space (C5), on the anterior axillary line on left and right, respectively. Prior to the performance of experimental protocols, the individuals remained in rest for 10 minutes for stabilization of vital signs (BP, HR and respiratory rate) and, thereafter the experiments were initiated. The capture of the RRI during the procedures was performed as follows: 60 seconds at rest; the maneuver execution time (15 seconds in the VM and 5 seconds in the MEP) and 300 seconds corresponding to the recovery period, which the individuals should return to the baseline values of HR and BP.

Data analysis

We analyzed the data regards to HR_{rest}, mean HR values within 60 seconds prior to the execution of each maneuver; HR_{peak}, the highest HR value obtained during the maneuvers; HR_{nadir}, the lowest value obtained after the interruption of the maneuvers; $HR_{recovery}$, mean of the final 180 seconds of the recovery period of each maneuver[26]; heart rate variation of (ΔHR), calculated by the difference between HR_{peak} during each maneuver and HR_{rest} [16,27]; $\Delta HR_{isotime}$, calculated by subtracting the HR value in the third second after the deep inhalation from the mean HR at rest; the indexes of the Valsalva maneuver (VI)[15,16,18,28,29] and of the MEP maneuver (MEPI), obtained by the ratio between the greatest RRI of the recovery period and the lowest RRI during the peak of the maneuver. The estimated workload (W) of the maneuvers was calculated by multiplying the expiratory pressure values observed in the maneuvers by the total time (W_{total}) or by 3 seconds ($W_{isotime}$). To evaluate the values of the workload performed in proportion to ΔHR, the ratios $W_{total}/\Delta HR_{total}$ and $W_{isotime}/\Delta HR_{isotime}$ were calculated.

Statistical analysis

The sample size calculation was based on the results of ΔHR (VM: 35.80 bpm; MEP: 23.73 bpm and combined standard deviation of 9.78 bpm) obtained in a pilot study (n=5), with β=0.8 and α=0.05. This calculation suggested a sample of 12 participants in each group (VM and MEP). For statistical analysis, the software SigmaPlot 11.0 (Systat, USA, 2011) was used. The Shapiro-Wilk test was used to verify the normality of data distribution and the two-way ANOVA for repeated measures with Holm-Sidak post-hoc to verify the effect of the maneuvers and positions. The significance level was 5%. Data are presented as mean and standard deviation.

Results

Table 1 presents age, anthropometric data of the volunteers, the MEP values obtained and the percentage in relation to the values predicted by Neder et al.[25]. With regards to the body mass index (BMI), the subjects were initially subdivided according to their BMI level in normal weight and overweight and tested the influence of this variable on the HR responses. Therefore, as no difference between the subgroups was found all the statistical analyses were performed considering only one group.

The HR values during the performance of the maneuvers are shown in Table 2. Figure 2 illustrates the HR responses observed during the maneuvers. A significant difference between the maneuvers for the HR_{peak} and HR_{nadir} values was observed. Among the positions, there were differences in the values of HR_{rest}, HR_{nadir} and $HR_{recovery}$. However, when comparing the positions intra maneuvers, there were differences for the values of HR_{nadir} and $HR_{recovery}$ in the VM and of HR_{rest} and $HR_{recovery}$ in the MEP. There were significant differences between the maneuvers for the values of ΔHR and $\Delta HR_{isotime}$. The indexes VI and MEPI were significantly different among the maneuvers, with interaction between position and maneuver. In the VM, the index VI had higher values in the supine position. The values of W_{total}, $W_{isotime}$ and the ratio $W_{isotime}/\Delta HR_{isotime}$ were different between the maneuvers.

Table 1. Age, anthropometric data, predicted and obtained MEP values at supine and sitting position.

	Subjects (n=12)
Age (years)	25±2
Height (m)	1.78±0.06
Body mass (kg)	78±9
Body Mass Index ($kg.m^{-2}$)	23.4±2.8
Predicted MEP* (cmH_2O)	131±2
Supine	
MEP (cmH_2O)	117±24
MEP (predicted %)	89±18
Sitting	
MEP (cmH_2O)	114±25
MEP (predicted %)	87±19

*MEP values predicted by Neder et al.[25].

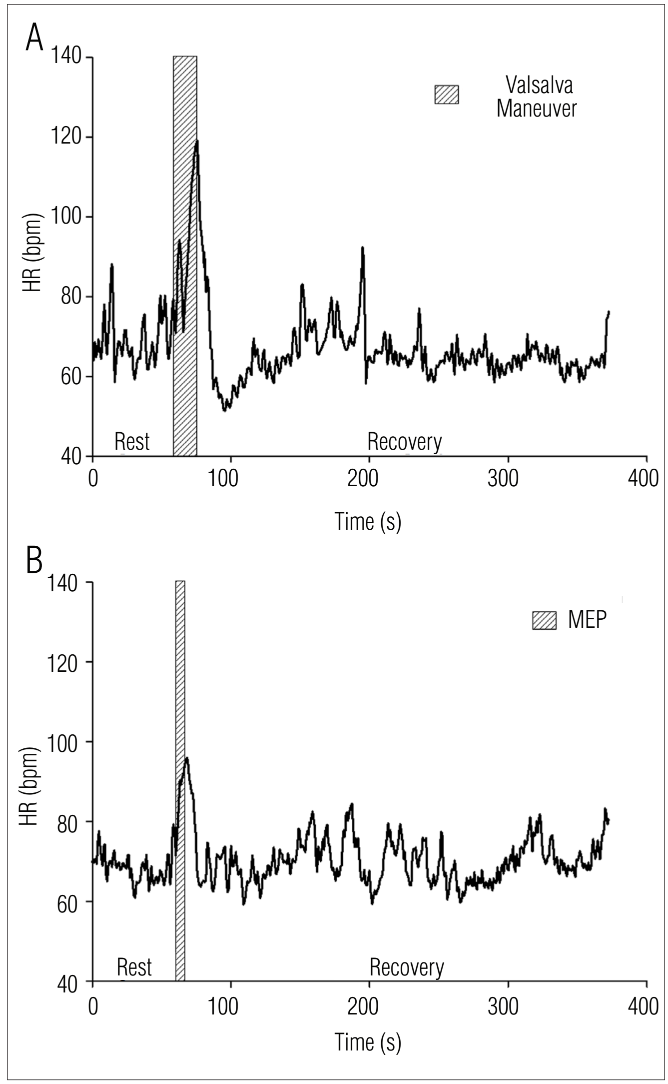

Figure 2. Beat to beat heart rate response during the execution of the Valsalva maneuver (A) and the MEP (B).

Discussion

The main findings of this study are: the performance of MEP does not reproduce the HR responses (ΔHR and indexes) observed in the VM. The results regarding to the workload and its ratios show an influence of execution time of the maneuver. Additionally, the HR responses (ΔHR and indexes), the workload responses and its ratios were not influenced by the studied positions.

Heart Rate

The HR response may be influenced by several factors, such as gender, age, genetic and anthropometric characteristics, changes of body posture, fitness level etc[16,17,19,20]. In the present study, the body postural change has influenced the HR_{rest}, HR_{nadir} and $HR_{recovery}$ responses, possibly due to the changes in the sympathetic and parasympathetic modulation promoted by the postural change[17,20,21].

However, during the execution of the VM the HR is influenced mainly by the autonomic modulation, being responsible not only for the phase of rapid increase (vagal withdrawal on the sino-atrial node) but also for the decrease of its values after interruption of the maneuver (resumption of the vagal modulation on sino-atrial node)[17,20,21]. These adjustments associated to the adjustment of blood pressure and the peripheral vascular resistance occur in response to the activation of the arterial baroreceptors (carotid and aortic) and of the cardiopulmonary receptors[14,15,22,23]. Moreover, other studies show that the interaction between the sympathetic reflex of the arterial baroreceptors and the vagal reflex, probably activated by the pulmonary stretch receptors, is the responsible for the cardiovascular actions during the VM[14,22].

In the present study, there were no differences in the indexes values (VI and MEPI) and ΔHR between supine and sitting positions. Our data agree with other studies, in which the influence of position on the VM was investigated[14,19]. These authors identified that the position does not interfere on HR and the HR response to VM is a compensatory mechanism that occurs in order to avoid hypotension due to decreased venous return.

The importance of the venous return on HR responses can be observed during the execution of the VM in the supine position. In this situation, the highest HR values during the maneuver (116±9 bpm) and the lowest HR values after the maneuver (52±4 bpm) were observed, which have resulted in higher values of VI (2.3±0.2). This response is probably due to the cardiovascular adjustments necessary to maintain the cardiac output during and after the interruption of the maneuver.

The increase of HR during the VM is accompanied by increase of peripheral vascular resistance (PVR) in response to the decrease of venous return and decrease of the left ventricular filling, due to the increase of intrathoracic pressure. With the interruption of the maneuver there is an increase in venous return and BP, which stimulates the vagal recovery via baroreceptors leading to accentuated bradycardia[14-16].

The VI is a parameter used in the indirect evaluation of the ANS integrity, characterized by values above 1.4[28]. The VI values obtained in this study (supine: 2.3±0.2; sitting: 2.0±0.2) are in agreement with values found in other studies[16,27,28] indicating that the individuals present intact ANS. Although there is no previous report in the literature about the MEPI values, our results (supine: 1.5±0.2; sitting: 1.6±0.3) showed lower values of the MEPI compared to the VI values. This difference (Table 2) is probably due to the highest sympathetic activation (increase of HR and PVR) and parasympathetic (vagal recovery) that happens in response to hemodynamic changes provoked by the increase of intrathoracic pressure during the VM[14-16,22].

Another important result of the present study showed that ΔHR is higher during the VM compared to the MEP regardless of the subject position. The ΔHR is influenced by hemodynamic adjustments that occur during the expiratory effort against resistance present in the maneuvers[15,16,22]. During the VM, these adjustments seem to happen in greater proportion than in the MEP measures, probably due to the longer duration of execution of this maneuver[29]. In the present study, the execution time of the VM (15 seconds) was approximately four times longer than in the MEP measures (4 seconds). Besides the execution time of the maneuver[29], others pre-conditions are necessary for the HR response be similar to the values found in the VM, such as high pulmonary volume during the maneuver, low expiratory pressure and normal cardiovascular reactivity[23].

Accordingly, Elghozi et al.[30] evaluated the cardiovascular responses of tuba players who should: a) to play low, medium and high notes for 15 seconds, and b) to execute the VM at pressures of 10, 40 and 60 mmHg for the same time. During the execution of high notes, the tuba players had similar responses to those found in the VM (40 and 60 mmHg). However, when playing low notes, the cardiovascular responses were minimal, approaching the responses observed in the VM of 10 mmHg. The difference between the performance of high and low notes is the pattern expiratory flow adopted, being higher during the low notes. The high expiratory flow pattern necessary to play the low notes is similar to the expiratory effort performed during the MEP measures found in this study.

Thus, although the volunteers of the present study have normal cardiovascular reactivity (indicated by the VI values)[23] and they have generated high pulmonary volumes (TLC) previously to the MEP measures, during the execution of these measures high expiratory pressure values were generated in very short periods of time. This characteristic, associated to the high expiratory effort flow pattern is probably responsible for a lower intrathoracic stress and lower proportion of cardiovascular adjustments compared to those that occur during the VM[31].

Table 2. Heart rate, index and workload responses observed on Valsalva maneuver and MEP measure at supine and sitting position.

	Valsalva maneuver		MEP		p-values		
	Supine	Sitting	Supine	Sitting	P	M	I
Heart Rate							
HR_{rest} (bpm)	70±10	72±8	65±4*	71±6	0.04	NS	NS
HR_{peak} (bpm)	116±9	113±13	89±9	95±10	NS	<0.001	NS
HR_{nadir} (bpm)	52±4*	57±5	58±5	59±4	0.03	0.002	NS
$HR_{recovery}$ (bpm)	67±7*	74±7	66±4*	75±5	<0.001	NS	NS
Heart rate variation							
ΔHR (bpm)	47±9	41±10	23±8	24±8	NS	<0.001	NS
$\Delta HR_{isotime}$ (bpm)	25±11	19±8	15±5	15±4	NS	0.002	NS
Index							
VI or MEPI	2.3±0.2	2.0±0.2*	1.5±0.2	1.6±0.3	NS	<0.001	0.002
Workload							
W_{total} ($cmH_2O.s$)	810±37	805±33	389±111	438±156	NS	<0.001	NS
$W_{total}/\Delta HR_{total}$ ($cmH_2O.s.bpm^{-1}$)	18.0±3.5	21.4±8.0	19.3±10.0	19.5±7.6	NS	NS	NS
$W_{isotime}$ ($cmH_2O.s$)	162±8	161±7	350±73	341±75	NS	<0.001	NS
$W_{isotime}/\Delta HR_{isotime}$ ($cmH_2O.s.bpm^{-1}$)	7.3±1.9	9.9±3.9	27.2±15.5	25.9±11.5	NS	<0.001	NS

Data expressed as mean±standard deviation. HR=heart rate; ΔHR=heart rate variation; VI=Valsalva index; MEPI=MEP index; W_{total}=total work; $W_{isotime}$=isotime work; $W_{total}/\Delta HR_{total}$=ratio between total work and total heart rate variation; $W_{isotime}/\Delta HR_{isotime}$=ratio between isotime work and isotime heart rate; P=posture effect: supine **vs** sitting; M=maneuver effect: VM **vs** MEP; I=interaction between postures and maneuvers; NS=non-significant; *<0.05 posture effect intra-maneuvers.

Workload

Regarding the estimated values of the workload performed during the maneuvers there was statistical significant differences between the maneuvers for W_{total}, but not for the $W_{total}/\Delta HR_{total}$ ratio regardless of the position adopted. In relation to W_{total}, it was observed that the highest values were found during the VM showing the influence of the execution time of the maneuver (15 seconds) on the comportment of this variable.

On the other hand, there was a statistical difference ($p<0.001$) between values of $W_{isotime}$ and $W_{isotime}/\Delta HR_{isotime}$, regardless of the position adopted. In this case, when we analyzed the workload in a same period of maneuver time (3 seconds), the highest values of expiratory pressure generated during the MEP (supine: 117±24 cmH_2O; sitting: 114±25 cmH_2O) were responsible for the highest values of $W_{isotime}$ and $W_{isotime}/\Delta HR_{isotime}$. Thus, the execution form of the maneuver, characterized by the longest time of execution and for the highest expiratory pressure generated in the VM and in the MEP, respectively, seem to be determinants of the workload measure.

However, although the highest values of $W_{isotime}$ and $W_{isotime}/\Delta HR_{isotime}$ occurred during the MEP, it is important to point out that the greatest variations of HR occurred during the VM. This probably occurs because the MEP is performed in short period of time and with high expiratory pressures that lead to lower intrathoracic stress. These conditions differ from those described by Looga[23] (high pulmonary volume during the maneuver, low expiratory pressure and normal cardiovascular reactivity), as been required for an expiratory maneuver reproduces the cardiovascular responses found in the VM.

Clinical implications and limitations

Although a simple method for evaluation of HR responses has been used, it allowed to formulate inferences about them, as well as to obtain important results on the comportment of this variable during the VM and the MEP. However, the present study was limited by the unavailability of equipments for continuous measurement of BP and intrathoracic pressure. These measures could provide additional information about the cardiovascular response during the execution of these maneuvers.

The results of this study allow inferring that the execution of the MEP does not reproduce the HR responses observed in the VM. Therefore, we can affirm that in relation to the cardiac stress, its application in clinical practice of physical therapy is safe when performed under similar conditions to the present study (subjects and methodology). Besides, the results found in this study can be used as reference for further studies about the HR response during the VM and the MEP measure performed in other age groups and/or clinical conditions.

Conclusion

Based on data concerning the HR responses (VI e ΔHR) and the estimated workload during the maneuvers, it can be concluded that the execution of the measures of MEP in young men, apparently healthy, does not reproduce the responses observed in the execution of the VM. Thus, it seems that the application of the MEP measures in this population is a safe evaluation procedure in the studied conditions.

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