Haemodynamic Parameters for Assessment of Orthostatic Intolerance in Older People

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Abstract

Orthostatic hypotension (OH) is a frequent cause of orthostatic intolerance (OI) and related symptoms associa/-ted with the occurrence of syncope. The purpose of this study was to examine if older people haemodynamic profile with symptoms of OI is different to controls during active stand. The database includes sample of 45 participants, aged at least 60 years, where 46.7% (n=21) had symptomatic OI and 53.3% (n=24) did not. Haemodynamic parameters were registered during three phases: a pre-exercise, walking phase and a post-exercise stand. Different haemodynamic parameters such as, pulse rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and cardiac output (CO) were extracted at each of the phases. Results showed differences along phases in both groups. Mean HR differences in phase 1-2 and phase 2-3 showed a statistical signification between symptomatic OI and non-symptomatic OI group. In addition, the combination of the variables rise/fall time-maximum/minimum amplitude in phases 2-3 showed opposite trends in men and women in symptomatic and non-symptomatic OI groups. These findings show the potential of haemodynamic parameters to classify symptomatic and non-symptomatic OI in older people.

1. Introduction

Orthostatic hypotension (OH) is the most common disorder of blood pressure regulation after essential hypertension, and it is an important clinical entity in older people. Its prevalence is reported between 5 and 30% increasing with age [1, 2] and it is an incapacitating disease. OH can result from an excessive fall in arterial blood pressure upon change of body position from supine to standing, it may occur as a primary (idiopathic) disease or may develop as a complication to other diseases.

It has been reported that initial OH is a frequent cause of orthostatic intolerance (OI) [3,4]. OI is a clinical syndrome that is characterized by symptoms and loss of consciousness before impending syncope are fundamentally due to cerebral hypoperfusion characterized by orthostatic symptoms such as dizziness, lightheadedness, palpitation, and blurred vision [5].

Alterations of the neural sympathetic cardiovascular control have been suggested to be one of the potential underlying pathophysiolgical mechanism in OI [6]. Compared with asymptomatic people, OI patients show impaired cardiac output and heart rate response [7–10].

OI has been extensively studied in young and middle aged people, nevertheless the mechanisms underlying OI in older people have been less researched. OI in older people is important as researchers have found that OI is more strongly associated with a history of falling and impairment of functional status than postural hypotension [11]. Recently, the underlying haemodynamic response during active stand in older people with OI has been examined [12, 13]. Women were shown to have greater arterial stiffness than men. Another emerging finding is that OI cannot always be predicted by OH [14, 15]. Nevertheless, research suggests that systolic blood pressure changes during active stand relate to OI and that the rate of recovery of systolic blood pressure during first 30 seconds following active stand is an important determinant of OI [16]. Therefore, it is important to elucidate which blood pressure changes are associated with OI in older people. However, because monitoring of beat-to-beat blood pressure is necessary for the objective assessment of OH, a procedure normally unavailable in routine clinical assessment should be established [3, 17].

The purpose of this study was to examine the haemodynamic profile of community dwelling older people with symptoms of OI undergoing an active stand and to investigate if their dynamic cardiovascular profile during a six minute walk would be different to controls.

2. Materials

The database includes sample of 45 participants, aged at least 60 years (69.5 ± 5.1), of whom 60% were women. There were no significant differences in age and gender between symptomatic and asymptomatic participants, where 46.7% (n=21) had symptomatic OI and 53.3% (n=24) did not. The measurement of the arterial pressure waveform was done at the finger with Finapress for Finger Arterial Pressure. This method enabled for the first time a reliable measurement of the beat-to-beat blood pressure signal in a noninvasive manner.

The participants were assessed at the Technology Research for Independent Living (TRIL) Clinic in St James Hospital Dublin. All participants had a Mini-Mental State Examination (MMSE) score of $\geq$ 23 points, which is an optimal cut off when screening for dementia in an Irish setting [18]. None of the participants had Parkinson diabetes mellitus, severe chronic renal failure (defined as Cockcroft Gault estimated Glomerular Filtration rate $<$ 30m/min), vitamin B12 or folate deficiency or a cardiac pacemaker. The participants were not asked to stop any of their usual medications or fast before the assessment. All persons gave informed consent before their inclusion in the study.

3. Methods

The participants underwent a lying to standing orthostatic test (active stand) with noninvasive beat-to-beat blood pressure monitoring by the $FinometerPro$ device (Finapres Medical Systems). Before standing, the participants were resting in a supine position for at least 10 minutes, and after standing, blood pressure was monitored for 3 minutes with participants standing still.

The blood pressures measured by the Finometer Pro device were calibrated at baseline (at least 2 minutes before the active stand) using the Return to Flow calibration system, which involves the use of an oscillometric pressure cuff on the ipsilateral upper arm for an individual calibration of the reconstruction of the finger pressure signal to brachial level [19]. The hydrostatic height correction system was used throughout the study to compensate for hand movements with respect to heart level, and a height nulling procedure was performed for each participant in the supine position and was recommended by the manufacturer.

The 6-min walk test is a simple tool for the evaluation of functional exercise capacity, which reflects the capacity of the individual to perform activities of daily living. In our study participants were equipped, while walking, with a Portapress device which is a validated portable blood pressure device to measure blood pressure non invasively using beat to beat haemodynamic monitoring system. The 6-min walk test was conducted according to the following protocol:

- The participant stood for three minutes pre-exercise.
- A 30 m. flat, obstacle-free corridor was used marked out in 5 m. increments. The participants was instructed to walk at their fastest comfortable pace, turning 180^o every 30 m. in the allotted time of 6 minutes.
- The participant stood for a further 3 minutes at the end of the test.

Three phases were captured: a pre-exercise stand lasting 3 minutes, a six minute walking phase and a post-exercise stand lasting 3 minutes. Haemodynamic parameters were exported with the Beatscope 1.1a software (Finapres Medical Systems) according to the 10-s average method outputted using Modelfow.

The following beat to beat derived haemodynamic measures were extracted:

1. Systolic blood pressure (SBP): as maximum pressure in arterial systole (mmHg).
2. Diastolic blood pressure (DBP): as low blood pressure just before the current upstroke (mmHg).
3. Heart rate (HR): pulse rate derived from the pulse interval (beats per minute) (pulse interval: time between the current and the next upstroke).
4. Cardiac output (CO): as the mean arterial pressure to cardiac output assuming zero venous pressure (at the right atrium) (mmHg*s/ml).

Derived haemodynamic parameters from delineated and smoothed curves were extracted at each of the following phases of the active stand test:

Phase 1: defined as the average, standard deviation, maximum and minimum values of each haemodynamic parameter during 3 minutes before active stand.

Phase 2: defined as the value of each haemodynamic parameter at the lowest point of systolic blood pressure reached following active stand and the mean of the parameters when the registers are stabilized.

Phase 3: defined as the value of each haemodynamic parameter at the highest point of systolic blood pressure reached from the time where parameters were stabilized following active stand.

Extracted haemodynamic parameters were analyzed to test any significant differences regarding symptomatic and non symptomatic OI, unpaired t-tests and repeated measures ANOVA coupled with the Student-Newman-Keuls test were used. Results were considered to be statistically significant at $p < 0.05$.

4. Results

Results showed differences between phases in both groups. The main differences between different phases were found in mean HR and in DBP and the combination of the variables rise/fall time and maximum/minimum amplitude in phases 2 and 3 in all the measured parameters showed opposite trends in men and women in both groups.

4.1. Mean Heart Rhythm

Mean HR differences (beats/min) in phase 1-2 showed statistical signification (p=0.032) between symptomatic OI group (phase 1: 74.11 ± 14.37 vs. phase 2: 109.68 ± 15.04) and non-symptomatic OI group (phase 1: 78.52 ± 11.70 vs. phase 2: 105.83 ± 11.47), moreover the same trend was observed in phase 2-3 with a statistical signification of p=0.016. Mean HR in symptomatic OI patients during phase 2 was $10,83 \pm 11.48$ and in phase 3, 89.34 ± 13.84 and in the control group mean HR during phase 2 was 109.68 ± 15.05 and in phase 3 was 84.86 ± 16.45. Moreover, it is possible to find statistical significant differences in minimum HR between phases 1-2 and 2-3 and maximum HR in phases 2-3 between both groups (Table 1).

Table 1. Mean HR, minimum HR and maximum HR differences between both groups.

Phase	Parameter	Groups		Sig.(p)
		OI	Control	
1-2	HR_{Mean1}	78.51 ± 11.70	74.11 ± 14.37	0.032
	HR_{Mean2}	105.83 ± 11.48	109.68 ± 15.05	
	HR_{Min1}	73.52 ± 12.13	69.51 ± 13.71	0.010
	HR_{Min2}	95.11 ± 7.96	99.97 ± 12.75	
2-3	HR_{Mean2}	105.83 ± 11.48	109.68 ± 15.05	0.016
	HR_{Mean3}	89.34 ± 13.84	84.86 ± 16.45	
	HR_{Min2}	95.11 ± 7.96	99.97 ± 12.76	0.005
	HR_{Min3}	84.92 ± 13.27	80.58 ± 14.74	
	HR_{Max2}	113.56 ± 12.38	116.47 ± 14.23	0.038
	HR_{Max3}	96.34 ± 14.90	91.45 ± 19.38	

4.2. Diastolic Blood Pressure

The evolution of DBP (mean DBP, maximum DBP and minimum DBP) along the three phases showed higher values in the control group than in than in symptomatic OI patients. In Figure 1 is represented mean DBP along the three groups with a statistical signification between the three phases of p=0,027 between symptomatic and non symptomatic OI patients.

4.3. Stabilization time in Phase 2 and 3

In addition, the combination of the variables rise/fall time and maximum/minimum amplitude in phases 2 and 3 showed opposite trends in men and women and in symptomatic and non-symptomatic OI groups in all the parameters. The rise time in phase 2 and the fall time in phase 3, combined with the value of the parameters in these points showed different trends in men and women in the OI group and in control group in all the variables, SYS, DIA, HR and CO.

For the OI group rise time was 59.96 ± 33.82s (women: 46.63 ± 16.80s and men: 75.73 ± 42.28s), and fall time was 61.30 ± 15.95s (women: 61.79 ± 10.39s and men: 60.71 ± 21.32s), and in the control group rise time was 56.85 ± 20.17s (women: 60.80 ± 23.10s and men: 48.97 ± 9.55s) and 64.24 ± 18.60s (women: 60.92 ± 19.33 and men: 70.87 ± 16.31) for the fall time.

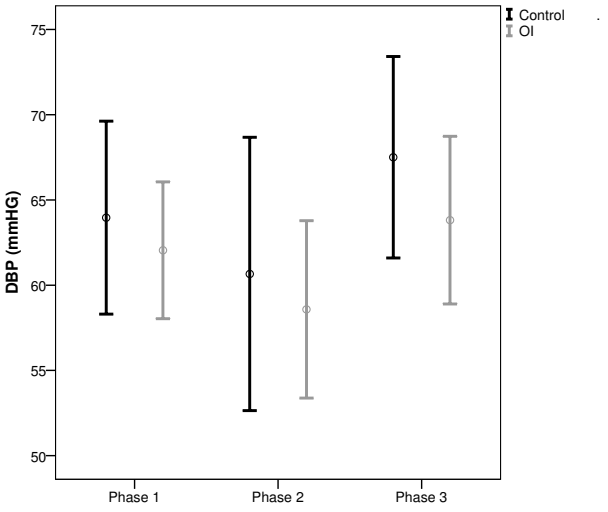

Figure 1. DBP during the three phases in control group (black) and OI group (grey).

In addition, the comparison of rise/fall time and amplitude variables in phases 2 and 3 showed statistical signification for all the variables, DBP (p=0.005), SBP (p=0.006), HR (p=0.047) and CO (p=0.017).

5. Conclusion

In this study we examined the haemodynamic response of 45 older people during a six minute walk functional exercise test. We analyzed the different profile of those participants with symptomatic OI and a non symptomatic OI group. Both groups had similar baseline characteristics including age, gender, Charlson Comorbidity Index, cognition and berg balance.

This study presents evidence that during the phase of exercise the mean HR response increases more in symptomatic OI participants compared with the non symptomatic OI, moreover the mean HR was higher in non symptomatic OI participants compared with the symptomatic OI before and following active stand.

Furthermore, during the first phase of exercise the diastolic blood pressure response is more pronounced in symptomatic OI participants compared with the non symptomatic OI.

In addition, rise time and fall time in phases 2 and 3 in combination with the other parameters followed opposite trends in women and men.

Identification of the mechanism that mediate OI is of

clinical importance as OI is a recognized risk factor for falls and impairment of functional status, especially in women [20]. There were trends pointing towards an association between symptomatic OI participants having a slower gait velocity, higher dizziness handicap inventory score, poorer self related health and physical exhaustion symptoms.

Our findings agree with comparative studies which have investigated the effect of exercise on the haemodynamic response to orthostasis. These studies predominantly looked at prolonged exercise but comparable haemodynamic profiles emerge. An attenuated heart response to exercise was found in older people with symptomatic OI [21].

As conclusion, this study provides important information on haemodynamic parameters and can be helpful for description of the haemodynamic changes that occur during orthostatic hypotension. OH increases the mortality rate in the elderly.

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