THE USE OF INDIRECT VIBRATION AS AN EXERCISE INTERVENTION IN PHYSICAL THERAPY

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Abstract: Background: The are many studies conducted on vibration, especially on vibration plates and its effects on performance. There is a restraint in the use of vibration in the physical therapy field because there are also risks associated with the use of vibrations. New research shows the possible benefits in the functional recovery by applying vibrations.
Objectives: The objective of the study is to demonstrate if indirect vibration through elastic bands in association with isometric contraction can be used safely as an exercise in physical therapy.
Patients and Methods: A case study was conducted on two healthy subjects and physically active but are opposite in terms of sex, weight, muscle strength and somatic type. Vibration parameters were measured on the upper limb to study the propagation of vibrations.
Results: There is a reduction on vibration amplitude from the results at input (hand) to the head. The average reduction in hand-arm-head is from an AVG(date) of 1.647 m/s2 to 0.556 m/s2 for level 1 and from 6.556 m/s2 to 1.3 m/s2 level 2) for case 1 (T.L.) and for case 2 (V.A.), from 1.135 m/s2 to 0.183 m/s2 for level 1 and from 1.207 m/s2 to 0.138 m/s2 for level 2).
Conclusions: Vibration ca be used safely as an exercise intervention in physical therapy if the dosage is adequate. Also, the vibrations dosage must be adjusted based on the age, sex and the muscle mass;
Keywords: v*ibrations, physical therapy, proprioception, neuroplasticity, functional recovery*

Introduction

Background

The possibility of using vibrations as an exercise intervention is a recent concept. The first application of vibration as an exercise intervention was conducted by Russian scientists. The scientists demonstrated that vibration was effective in enhancing strength in well-trained subjects.[1][2]

Functional recovery focuses on motor aspects, neglecting the sensory function that is essential for the recovery. For the functional rehabilitation program to be effective, it must have an optimal sensory feedback.

Research has begun to focus on the possibility of using vibration in treating motor deficiencies through the stimulation of somatosensory wich promotes neuroplasticity and vibrations are the most rapid means of stimulating the proprioception.

Vibrations can be applied through elastic bands while the muscle is in isometric contraction wich can facilitate the motor response by stimulating the somatosensory process.

Vibration

Vibration is a periodic movement of an object, carried around an equilibrium position.[3] The extent of the oscillatory motion determines the amplitude of the vibration (measured in m/s2), the repetition rate of the cycles of oscillation determines the frequency of the vibration (measured in Hz).

Posible benefits from applying vibration in association with isometric contraction

Vibration represents a strong stimulus for musculoskeletal structures due to the need to quickly modulate muscle stiffness to accommodate the vibratory waves. According to the World Health Organization statistics, Romania ranks first in the incidence of stroke." [4] Posible effects to reciprocal inhibition can be evoked wich can ameliorate spasticity for example, wich affects 25% of stroke patients within the first 6 weeks after the event.[5]

Objectives:

The objective of the study is to demonstrate if indirect vibration through elastic bands in association with isometric contraction can be used safely as an exercise in physical therapy.

Materials and Methods

Subjects: Two healthy subjects volunteered to participate in the study. The subjects were physically active and are opposite in terms of sex, weight, muscle strength and somatic type. Each subject was informed about the tests in this study with its possible benefits and risks.

	Subject 1 T.L.	Subject 2 V.A.
sex	feminine	masculine
age	37 years	32 years
weight	49 kg	96 kg
somatic type	ectomorph	endomorph
hand length	18 cm	18 cm
forearm length	23 cm	27 cm
arm length	20 cm	33 cm
forearm circumference	22 cm	34 cm
arm circumference (muscle in rest phase)	21 cm	39 cm
arm circumference (muscle in contracted phase)	23 cm	43 cm

Materials used: Vibration device with an eccentric rotating mass motor, model MG1001, with a power of 150W which produce mechanical vibration in two selectable levels. Blue elastic band (Physio brand) were used, wich was tied to the vibration device.
Warm-up protocol: All subjects performed a 5 minute warm-up including joint active mobilization and stretching to the upper limb. After a 3 minutes pause, the tests were conducted.
Performed tests: Vibration amplitude and frequency measures were made using a 3-axial accelerometer, model MTK v3, 3.3G. The sensor was placed on 3 different locations (first the hand, then the arm and head, fig. 1)

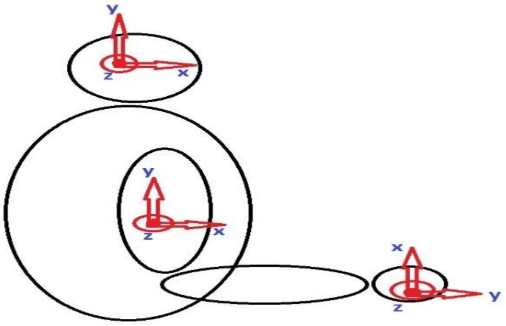


Fig. 1 Positioning of the sensor and the orientation of the axes.

Testing protocol: From a sitting position with an elastic band handheld, indirect vibrations were applied through elastic bands as a means of propagation vibration. Measurements with the elastic band in different positions relative to the vibration device were made (band stretched at 70, 80, 90 and 100 cm). Also all measurements were performed at level 1 (10 Hz), then repeated the process for level 2 (15 Hz). Between each test was given a pause of 30 seconds so that the muscle fatigue should not influence the test.

Results

Tb	70-80-90-100	p	b	c
Test name, results are in m/s2	Length of the band in cm	Position of the sensor on the hand	Position of the sensor on the arm	Position of the sensor on the head

RMS	Peak	AVG(date)	Hz
Root mean square	Max amplitude	Average of the measurements	Frequency of the vibration

CASE 1		PEAK		AVG

T. L. m/s2				PEAK
Tb.1.70.p	12.72	5.98	6.74	8.48
Tb.2.70.p	19.46	9.81	9.35	12.87
Tb.1.80.p	14.86	5.36	9.81	10.01
Tb.2.80.p	19.46	10.73	13.33	14.51
Tb.1.90.p	15.78	7.05	7.2	10.01
Tb.2.90.p	19.46	10.42	15.02	14.97
Tb.1.100.p	16.4	6.59	10.11	11.03
Tb.2.100.p	19.46	8.73	13.02	13.74
AVG(date)	17.2	8.08	10.57	
Tb.1.70.b	2.3	11.34	1.84	5.16
Tb.2.70.b	2.3	14.4	2.45	6.38
Tb.1.80.b	3.98	12.1	1.38	5.82
Tb.2.80.b	3.22	14.4	2.14	6.59
Tb.1.90.b	3.22	12.56	3.22	6.33
Tb.2.90.b	3.52	14.1	2.76	6.79
Tb.1.100.b	4.29	12.26	2.45	6.33
Tb.2.100.b	4.44	16.24	2.91	7.86
AVG(date)	3.41	13.43	2.39	
Tb.1.70.c	1.23	10.27	1.68	4.39
Tb.2.70.c	1.23	10.42	1.99	4.55
Tb.1.80.c	1.38	10.42	1.99	4.6
Tb.2.80.c	1.84	10.57	2.3	4.9
Tb.1.90.c	1.53	10.42	1.84	4.6
Tb.2.90.c	1.84	10.57	1.68	4.7
Tb.1.100.c	1.38	10.42	1.99	4.6
Tb.2.100.c	1.68	10.73	1.99	4.8
AVG(date)	1.51	10.48	1.93	

CASE 1 T. L. m/s2		RMS		AVG RMS	HZ
Tb.1.70.p	1.3	0.96	1.2	1.15	15
Tb.2.70.p	7.9	4.5	5.4	5.93	15
Tb.1.80.p	2	0.71	2.4	1.7	15
Tb.2.80.p	7.6	6.4	8.1	7.37	16
Tb.1.90.p	2.2	1	2.1	1.77	15
Tb.2.90.p	8.2	5	7.8	7	15
Tb.1.100.p	2.3	1	2.6	1.97	15
Tb.2.100.p	7.9	3.3	6.6	5.93	15
AVG(date)	4.93	2.86	4.53		15.13
Tb.1.70.b	1	0.47	0.17	0.55	10
Tb.2.70.b	1.1	2.4	0.56	1.35	16
Tb.1.80.b	0.77	0.86	0.15	0.59	10
Tb.2.80.b	0.7	2.5	0.61	1.27	16
Tb.1.90.b	0.71	0.87	0.57	0.72	10
Tb.2.90.b	0.72	2.4	0.56	1.23	15
Tb.1.100.b	0.76	0.94	0.37	0.69	10
Tb.2.100.b	1.1	3.6	1.1	1.93	16

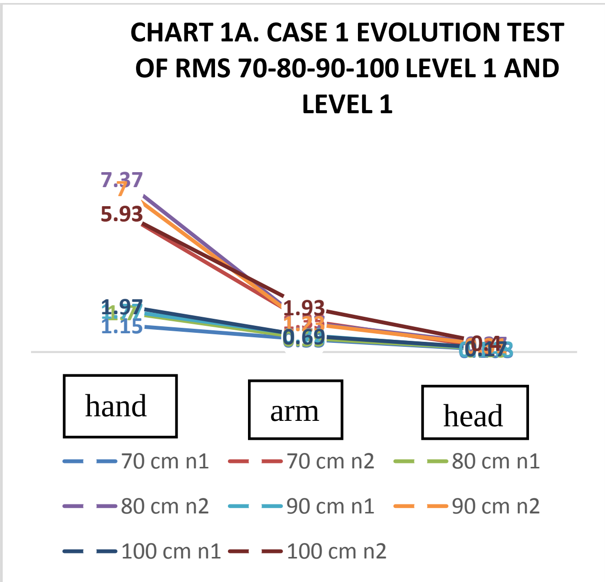
AVG(date)	0.86	1.76	0.51		12.88
Tb.1.70.c	0.085	0.14	0.1	0.108	11
Tb.2.70.c	0.19	0.29	0.19	0.22	16
Tb.1.80.c	0.08	0.18	0.13	0.13	10
Tb.2.80.c	0.4	0.43	0.28	0.37	16
Tb.1.90.c	0.094	0.22	0.13	0.148	10
Tb.2.90.c	0.37	0.37	0.2	0.31	16
Tb.1.100.c	0.1	0.26	0.16	0.17	10
Tb.2.100.c	0.38	0.52	0.29	0.4	15
AVG(date)	0.212	0.3	0.19		13

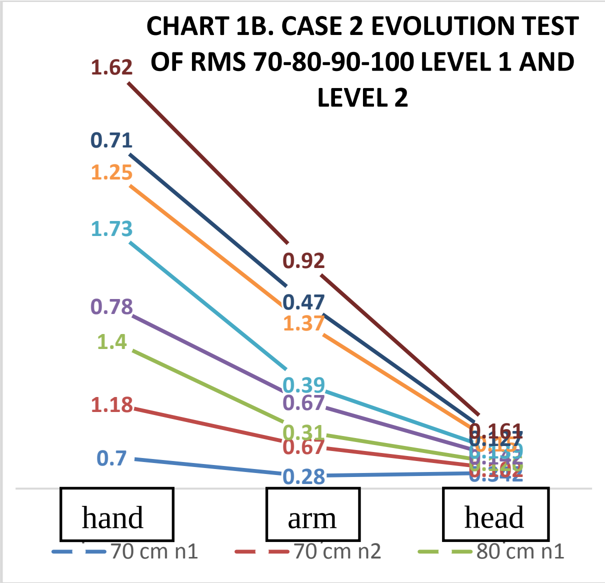
CASE 2 V.A. m/s2		**PEAK**		**AVG PEAK**
	X	**Y**	**Z**	**X,Y,Z**
Tb.70.1.p	11.95	2.14	3.37	5.82
Tb.70.2.p	14.71	2.76	1.68	6.38
Tb.80.1.p	14.25	5.21	3.22	7.56
Tb.80.2.p	11.8	3.52	2.3	5.87
Tb.90.1.p	15.63	5.98	5.06	8.89
Tb.90.2.p	12.56	3.83	5.82	7.4
Tb.100.1.p	12.41	3.53	2.45	6.13
Tb.100.2.p	16.24	4.44	2.3	7.66
AVG(date)	13.69	3.93	3.28	
Tb.70.1.b	4.75	9.5	2.91	5.72
Tb.70.2.b	4.44	11.03	3.06	6.18
Tb.80.1.b	3.83	9.81	3.37	5.67
Tb.80.2.b	4.29	10.73	3.22	6.08
Tb.90.1.b	5.21	9.65	2.76	5.87
Tb.90.2.b	5.82	12.1	2.76	6.89
Tb.100.1.b	4.75	9.65	3.68	6.03
Tb.100.2.b	4.75	11.8	3.98	6.84
AVG(date)	4.73	10.53	3.22	
Tb.70.1.c	2.76	9.96	1.68	4.8
Tb.70.2.c	3.83	10.11	2.45	5.46
Tb.80.1.c	4.14	9.81	0.77	4.91
Tb.80.2.c	3.22	9.81	1.07	4.7
Tb.90.1.c	4.29	9.5	0.92	4.9
Tb.90.2.c	4.44	9.65	1.07	5.05
Tb.100.1.c	4.29	9.5	1.53	5.11
Tb.100.2.c	4.44	9.5	1.07	5
AVG(date)	3.93	9.73	1.32	

CASE 2 V.A. m/s2		**RMS**		**AVG RMS**	**HZ**
	X	**Y**	**Z**	**X,Y,Z**	**X,Y,Z**
Tb.70.1.p	0.76	0.63	0.71	0.7	13
Tb.70.2.p	2.1	0.94	0.51	1.18	14
Tb.80.1.p	2.2	1.2	0.8	1.4	9
Tb.80.2.p	0.9	0.44	1	0.78	15
Tb.90.1.p	2.9	1.4	0.9	1.73	10

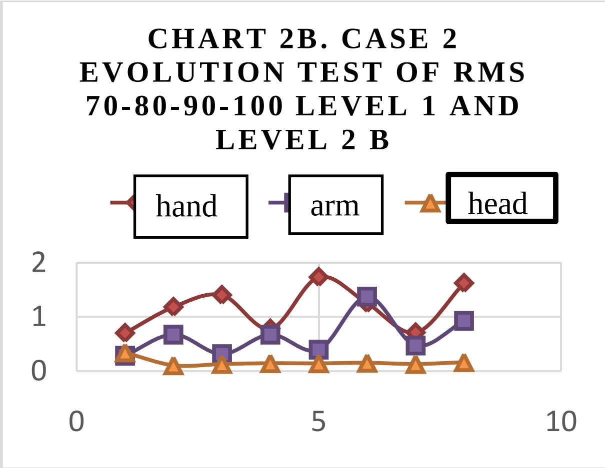
Tb.90.2.p	1.4	0.35	2	1.25	14
Tb.100.1.p	0.98	0.53	0.61	0.71	10
Tb.100.2.p	2.9	1.4	0.57	1.62	14
AVG(date)	1.77	0.86	0.89		12.38
Tb.70.1.b	0.29	0.26	0.3	0.28	10
Tb.70.2.b	0.67	1.2	0.15	0.67	14
Tb.80.1.b	0.27	0.28	0.38	0.31	10
Tb.80.2.b	0.47	1.1	0.45	0.67	14
Tb.90.1.b	0.42	0.33	0.41	0.39	10
Tb.90.2.b	1.1	2	1	1.37	14
Tb.100.1.b	0.61	0.32	0.47	0.47	10
Tb.100.2.b	0.5	1.7	0.55	0.92	14
AVG(date)	0.54	0.9	0.46		12
Tb.70.1.c	0.15	0.077	0.8	0.342	10
Tb.70.2.c	0.11	0.1	0.095	0.102	15
Tb.80.1.c	0.18	0.11	0.089	0.126	10
Tb.80.2.c	0.25	0.11	0.065	0.142	15
Tb.90.1.c	0.23	0.1	0.088	0.139	10
Tb.90.2.c	0.24	0.11	0.09	0.15	15
Tb.100.1.c	0.2	0.1	0.082	0.127	10
Tb.100.2.c	0.27	0.12	0.093	0.161	15
AVG(date)	0.2	0.103	0.175		12.5

Interpetation:

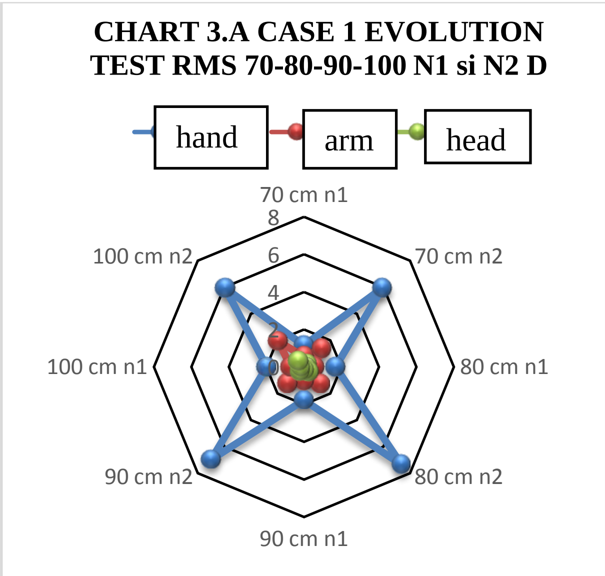


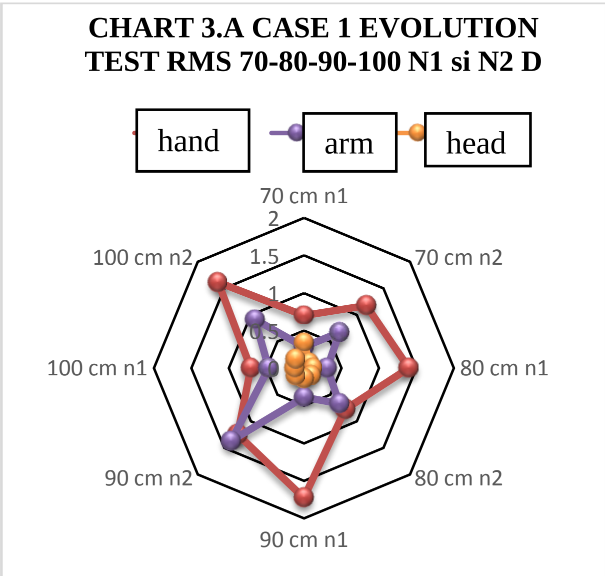


The study demonstrated in the diagram of the upper limb absorb much vibration.
In this chart (1a and 1b) is the propagation of vibration through the hand-arm-head system, expressed in RMS m/s2 and demonstrates that the upper limb absorb much of the vibration until it reaches the head.
The average reduction in hand-arm-head is (from an AVG(date) of 1.647 m/s2 to 0.556 m/s2 for level 1 and from 6.556 m/s2 to 1.3 m/s2 level 2) for case 1 (T.L.).
The average reduction in hand-arm-head is (from an average of 1.135 m/s2 to 0.183 m/s2 for level 1 and from 1.207 m/s2 to 0.138 m/s2 for level 2) for case 2 (V.A.).
This values is considered safe by the European Directive 2002/44/EC3 published on 25.06.2002 (minimum health and safety requirements regarding the exposure of workers to the risks arising from vibration).



In the chart (2a and 2b) there is a wide variation in amplitude to the hand and arm. The value at the head is constant, and is influenced slightly by the input vibration. This makes the application of vibration a safe measure to use as exercises in physical therapy.





In chart 3.a shows an increase in the amplitude of vibration in all level 2 vibration tests. In chart 3.b is a more random distribution of vibration amplitude. This shows that in case 1 (T.L.) the muscle mass and muscle strength counts, it is more sensible at a stronger amplitude and frequency.

The same is in the frequency analysis, case 2 (V.A.) has a vibration frequency of ~10 Hz (level 1) and ~15Hz (level 2) throughout the tests. In case 1 (T.L.), the vibration is ~15 Hz for the hand (level 1 and 2), ~10 Hz (level 1) and ~15Hz (level 2) for the arm and head.

Conclusions

By interpreting the results obtained in the case study on the propagation of vibration by the hand-arm-head system it was concluded that:

1. The vibration parameters dosage are representative of an important factor both in terms of efficiency but also to limit the level of risk associated with exposure to vibration;
2. The low vibration amplitude at head level makes the use o vibration safe as an exercises intervention.
3. The dosage (level vibration amplitude and frequency, resistance and stretching of the band) must be carried out according to age, sex and especially depending on the muscle mass;
4. Although vibration is transmitted indirectly linear vibration in all axes appears but with much smaller amplitude.

Discussions

More efficient functional recovery options decrease the costs and increase the quality of life. Also, it is easily applied, the investment cost is low and it can be dosed incrementally. It can be used independently or in association with other exercises.

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