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The effect of vibration on back discomfort and serum levels of von Willebrand factor antigen: a preliminary communication

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Summary. The von Willebrand factor (vWf) is a complex protein whose release is a marker for endothelial damage; serum levels of its antigen (vWFAg) can be used as a marker for such changes. We measured the levels of back discomfort and vWFAg in 11 subjects following 25-min periods of (1) lying down, (2) sitting upright, (3) vibrating whilst sitting and (4) sitting upright. Back discomfort appeared and vWf levels were significantly increased following sitting upright, compared with lying flat, and increased further following vibration. They fell thereafter with a period of sitting still upright. These results demonstrate that vibration has a significant effect in increasing back discomfort and the serum levels of vWFAg, and it is possible that vibration may induce vascular damage within the spine.

Key words: Low back pain – von Willebrand factor antigen – Vibration – Vascular damage – Endothelium

Many epidemiological studies have demonstrated a relationship between whole body vibration and low back pain. Such studies include those of drivers of tractors [3, 8–10, 12], trucks [3, 4, 8] and airplanes [2]. These studies also suggest that low back pain occurs at an earlier age in people who are exposed to vibration. Although concrete evidence is not available, there is reason to believe that back symptoms are caused or exacerbated by vibration [3, 4, 8, 9]. Vibration has also been shown to affect disc nutrition adversely and may cause earlier disc and vertebral aging and/or degeneration [4]. Nerve conduction is likewise adversely affected in workers using hand-held vibration instruments [13].

Degenerative changes of the spine have been correlated to vibration exposure, as have increased muscle activity, increased oxygen consumption and increased neuropeptide production. Recent studies suggest vascular damage and in particular venous obstruction and dilation with endothelial damage, fibrin deposition and intravascular thrombosis play an important role in the pathogenesis of many mechanical back pain syndromes [6]. The von Willebrand factor antigen (wVFAg) is a complex protein which can be affected by endothelial damage with a change of normal homeostasis, and serum levels of vWFAg can be used as a marker of such changes [14]. This is clear in inflammatory connective tissue disease where high levels of vWFAg reflect a severer stage of the disease [1]. There is no evidence that trauma or stress affect the levels of vWFAg other than by inducing endothelial damage.

We therefore sought to determine whether vibration might predispose the individual to spine problems by causing vascular activation. We measured back discomfort and the serum levels of vWf in 11 subjects before and following exposure to seated vibration.

Materials and methods

Eleven non-smoking normal subjects (6 male and 5 female) were exposed to four interventions to detect the effects of posture on back discomfort and vWf levels. All were free of low back pain and sciatica and had no history of back ailments, clotting abnormalities or medication usage that could affect the production of vWf. The age range was 20–49 years with a mean age of 30 years.

An open intravenous line with a heparin lock was maintained throughout the protocol. The subjects adopted a recumbent posture for 25 min following which they completed a visual analogue scale (VAS) to assess low back discomfort. A 10-ml blood sample was drawn at that time. After the first blood sampling, the subject sat upright on a seat for a further 25 min. A video programme was provided on a monitor to help the subject maintain a consistent posture and to make the experience more interesting. At the end of this period, the blood sampling and VAS were repeated. The subject was then vibrated at 5 Hz at levels of 3.5 m/s^2 rms for 25 min in an upright unsupported posture (Fig. 1). This vibration exposure was at the level of the fatigue, decreased proficiency limit recommended by the International Standards Organization [7]. It is roughly comparable to a ride on an unpaved highway in a truck for 25 min. Many occupations exceed this level of exposure. At the end of this period, the VAS and blood sampling were repeated. Finally, the subject again adopted a sitting posture for 25 min and the VAS and the blood sampling were repeated.

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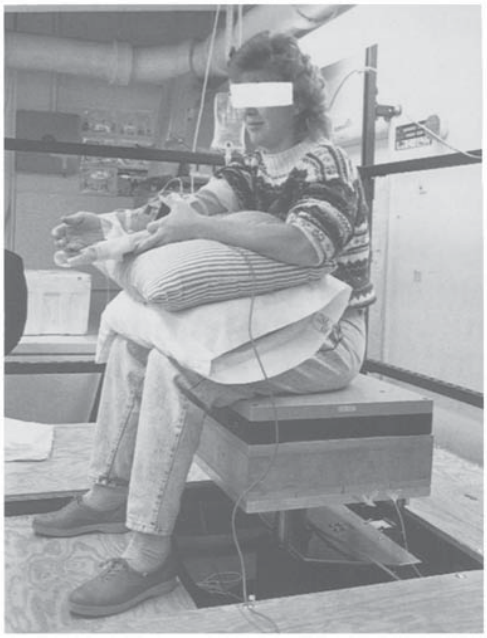

Fig. 1. The subject on the vibrating seat with the heparin intravenous line in place

The blood was prepared and shipped frozen (–70° C) to MIVJ at the University of Manchester. It was assayed (by A. D. B.) for vWf levels by an established ELISA technique [1].

The hypotheses tested were that back discomfort and serum vWf levels would increase after whole body vibration but would recover after a period of rest. Subjects acted as their own controls, thus increasing the power of the procedure.

Table 1. Back discomfort level via 10-cm visual analogue scale

Subject	Lying down (face up)	Sit still	Sit and vibrate	Sit still
1	0.50	0.40	6.80	2.30
2	0.90	3.20	1.50	2.00
3	2.00	2.10	5.00	
4	1.00	2.70	6.50	4.50
5	0.00	2.70	0.60	0.00
6	1.00	0.50	5.00	3.20
7	3.00	1.80	6.20	2.10
8	0.10	3.40	2.00	2.10
9	1.60	1.10	2.30	
10	0.60	2.00	4.50	0.40
11	2.00	3.10	2.40	0.30
Mean	1.50	1.97	3.89	1.88
Std Dev	0.91	1.05	2.20	1.46
Median	1.00	2.00	4.50	2.10
P	< 0.050	< 0.010	< 0.025	

Statistical significance of differences were calculated by *t*-test. The back discomfort levels increased from the initial lying-down period to the sitting-up period ($P < 0.050$). Back discomfort levels were significantly higher after exposure to 25 min of vibration, compared with the pre-vibration levels ($P < 0.010$), and fell again after the post-vibration rest period ($P < 0.025$)

Table 2. vWf levels (KIU/l) on vibration samples

Subject	Lying down (face up)	Sit still	Sit and vibrate	Sit still
1	74	83	111	110
2	88	100	119	94
3	127	136	143	140
4	67	104	105	106
5	51	101	102	90
6	144	148	157	133
7	89	101	109	100
8	76	80	79	77
9	118	123	132	132
10	106	105	115	106
11	109	101	127	133
Mean	95	107	118	111
Std Dev	27	20	20	20
Median	88	101	115	106
Range	51–144	80–148	79–157	77–140
P	< 0.05	< 0.01	< 0.05	

Reference sample: National Institute for Biological Standards and Controls, Blanche Lane, South Mimms, Potter Bar, Herts, UK

Results

Tables 1 and 2 give the back discomfort and vWf levels. Statistical differences were calculated by Wilcoxon's rank sum test for paired data. The levels increased from the initial lying-down period to the sitting-up period ($P < 0.050$). The vWf levels were significantly higher after a 25-min exposure to vibration, compared with the pre-vibration levels ($P < 0.010$), and fell again after the post-vibration rest period ($P < 0.050$).

Discussion

These preliminary results demonstrate that vibration exposure leads to elevated back discomfort and vWf levels. The resting vWf values were not in the pathogenic range (< 1.56 IU/dl) [1]. This would be expected as the studies were undertaken on normal subjects. The results indicate that a degree of vascular activation has occurred. It will clearly be of value to extend this study to a population of back pain sufferers, particularly those in whom vibration exposure appears to play a pathogenic role. This will enable us to see if the response is higher in these groups.

The results also emphasize the need to standardize the venepuncture technique for vWf assays. Most specimens from in-patients are taken with the patient lying down in bed and from out-patients when sitting. Is is clear that vibration (i.e. driving to the clinic and sitting) can influence the marker.

These results are in accordance with a previous report showing increases in vWf levels in a group of industrial riveters after a period of exposure to upper limb vibration (i.e. riveting). No increase in vWf was found in non-riveting controls in the same industrial setting and suggests

that the vibration associated with riveting is also a sufficient stimulus to cause injury to the endothelium [11].

Our vibration response results have important implications for people exposed to long-term whole-body vibration. They suggest that vibration to a level of discomfort can cause endothelial damage detectable by a serum marker. Since the subjects received whole-body vibration, we cannot be certain which tissues were excited. The frequency chosen does not resonate the internal organs, and the buttocks' motion is minor since the hard seat forces the subject to bear weight in the ischial tuberosities. It is possible that vibration is playing a pathogenic role in the vascular changes occurring around the nerve roots since vWf can aggregate platelets and mediate their adhesion to the subendothelium[14]. It is noteworthy that, in an animal model [15], whole-body vibration stimulated the release of neuropeptides from the dorsal root ganglion. Other, more localized forms of vibration may well be important and will require further study. Further studies will be necessary to elucidate a clear correlation between vWf and vibration.

This study is another step toward two goals: (1) correlating the International Standards Organization vibration limits (which are now psychophysically based) to objective, in vivo responses and (2) development of a simple tool for characterising the response to vibration exposure on the job. This method may also prove useful in assessing other repetitive task conditions such as hand-arm vibration and repetitive lifting or bending. In the future, it may be possible to construct a dose-response curve using this objective measure.

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