ACUTE EFFECTS OF FORCE AND VIBRATION ON FINGER BLOOD FLOW

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Introduction

Hand-arm vibration syndrome (HAVS) are prone to occur in people engaging in occupations that require prolonged exposure to hand-held vibrating workpieces[1, 2]. Considering holding a power hand tool, the amount of force exertion should be large enough in order to avoid sliding[3]. Also, how hard a subject grasps the tool affects the amount of vibration energy entering the hands; therefore, the applied force is an important factor in the exposure assessment, in addition to the vibration itself. However, little research has been done on the relationship between acute vascular response and active forces applied. This study is aimed to investigate the acute effect of two active forces (grip and push exertions) on finger blood flow (FBF) during exposure to a 125 Hz hand-arm vibration (HAV). It was hypothesized force would play a more important role in vascular effects than vibration, and grip force rather than feed force would have more effect on the vascular system.

Methods

An electrodynamic shaker producing 125 Hz vibration (22 m/s^2 unweighted) along the z-axis was positioned horizontally as shown in Figure 1 below. Subjects were required to grasp and push a handle fixed to the shaker using their right hands with the bent-arm posture, while having their left arms and hands supported at the heart level. Different exposure conditions are shown in Table 1.

Figure 1 The experimental set-up.

Up to 12 healthy subjects without vibration history attended the experiment. Each subject went through all the exposure conditions, each containing a period of seven minutes: (1) 2-min pre-exposure with no force or vibration, (2) 3-min exposure to force (and vibration), (3) 2-min recovery with no force or vibration.

Test of FBF was presented by strain-gauge plethysmography and measured in both hands of subjects every 30 s throughout the periods.

Table 1 The eight force-and-vibration situations experienced by subjects.

G10 + P10 (C11)	G50 + P50 (C55)	G10 + P50 (C15)	G50 + P10 (C51)
G10 + P10 + HAV (V11)	G50 + P50 + HAV (V55)	G10 + P50 + HAV (V15)	G50 + P10 + HAV (V51)

G: grip force; P: push force.

Results

Figure 2 below shows the percentage change in blood flow (%FBF) in both hands. Data analysis was conducted using non-parametric in SPSS. The Friedman test and the Wilcoxon signed ranks were performed between conditions with different exposures.

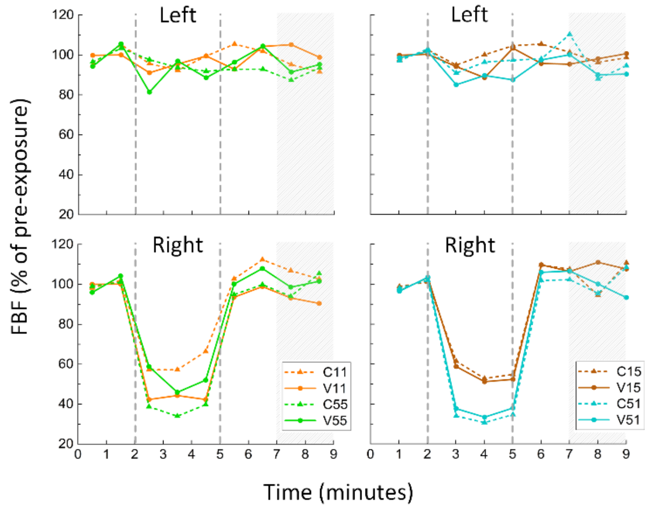

Figure 2 Percentage change of blood blow (% of pre-exposure) in the left (unexposed) fingers and right (exposed) fingers across the 7-min period and the eight exposure conditions. The pre-exposure period of each following round (grey area) is considered as the latter part of the recovery period of the previous round. Plotted symbols are median values of FBF.

Prior to the exposure, the vascular measurements showed no significant changes in %FBF in all fingers across the eight experimental conditions (p = 0.052–0.716, Friedman).

Exposure to hand force alone caused a significant reduction of FBF in right fingers, in which increasing hand forces (condition C55) was associated with a greater decrease (p = 0.002, Wilcoxon). Reductions of FBF were similar between conditions both with 10 N grip force, and between conditions both with 50 N grip force (p = 0.153–0.753, Wilcoxon), indicating that the grip force may have more effect in altering the FBF.

Hand force combined with 125 Hz vibration caused a decrease of FBF (p = 0.012, Wilcoxon), but the overlay effect of vibration on FBF in exposed fingers was not significant (p = 0.189–0.668, Wilcoxon) except for the pair C51 and V51 (p = 0.030, Wilcoxon).

After the exposure, FBF in right fingers recovered fast and fluctuated within the normal range (p = 0.012, Wilcoxon). Unexposed left fingers did not show significant reductions in median %FBF as a result of exposure.

Discussion

The combination of grip and push force had a strong correlation with circulatory effects, which is in contradiction with the previous study in which the hand force had shown little effect on blood circulation[4, 5]. But different contact conditions were applied here.

Generally, hand force played a more important part in circulatory effects than the vibration. Hand forces resulted in clear reductions in FBF while the additional reductions in FBF from vibration were not significant. A larger grip force would lead to a greater impact on the circulation than push force, which indicates that it is necessary to minimize the grip force applied to the tool handle to reduce the risk of harm from HAV.

References

[1] Griffin, M. J. & Erdreich, J. 1991. Handbook of human vibration. Acoustical Society of America.

[2] Pelmear, P. & Wasserman, D. 1998. A Comprehensive Guide for Occupational Health Professionals. OEM Press, Beverly Farms, MA, USA.

[3] Radwin, R. G., Armstrong, T. J. & Chaffin, D. B. 1987. Power hand tool vibration effects on grip exertions. *Ergonomics,* 30**,** 833-855.

[4] Thompson, A. J. & Griffin, M. J. 2009. Effect of the magnitude and frequency of hand-transmitted vibration on finger blood flow during and after exposure to vibration. *International archives of occupational and environmental health,* 82**,** 1151-1162.

[5] Ye, Y. & Griffin, M. J. Changes in finger blood flow induced by low magnitude localised vibration of the thenar eminence of the hand. 44th United Kingdom Conference on Human Responses to Vibration, Loughborough, 2009. 7-9.