The effect of road bike damping on neuromuscular activation and power output

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Background: In cobblestone cycling races like Paris-Roubaix, vibrations do not only cause discomfort, but are also a potential performance-limiting factor by increasing neuromuscular demands (Munera et al., 2018, Sperlich et al., 2009). Seatpost and handlebar damping reduce vibrations on the upper body, but not on the lower extremities (Viellehner & Potthast, 2018). It is thus not clear if damping contributes solely to comfort or also to short-term neuromuscular performance.

Purpose: The study aimed to investigate whether vibration and damping affect muscular activation and if damping contributes thereby to performance.

Methods: Based on a cross-sectional, single cohort design, the two independent variables vibration (Vib vs. NoVib) and damping (Damp vs. NoDamp) were analyzed. To examine their interaction effects on the dependent variables muscular activation and maximum short-term power output, 30 experienced cyclists (mass 75.9 ± 8.9 kg, height 1.82 ± 0.05 m, Vo2max 63 ± 6.8 ml/min/kg) performed tests with and without vibration. The vibration was applied to the front- (44 Hz, 4.1 mm) and rear-dropout (38 Hz, 3.5 mm) of a damped (Specialized Roubaix Comp, 2017) and non-damped (Specialized Tarmac Pro Race, 2015) bike.
The vibration characteristics were derived from outdoor test rides on cobblestones, during which the accelerations of the frame dropouts were recorded. Cranking power was defined for each subject at 40% (137 ± 14 W) and 60% (221 ± 18 W) of Vo2max. The results presented refer to the low-intensity powerlevel, but are applicable for threshold power as well. Muscular activation (Myon, Schwarzenberg, CH, 1000 Hz, Butterworth 5-500 Hz bandpass, 2nd order, recursive) of gastrocnemius lateralis, soleus, vastus lateralis, rectus femoris and triceps brachii were recorded over 15 pedal cycles and are reported as the mean activation of the signal envelopes (Butterworth 15 Hz lowpass, 2nd order, recursive) over the pedal cycle. EMG amplitudes are normalized to the peak activation of the NoVib x NoDamping baseline condition at threshold power. As a performance metric, the cranking power during a 20 second seated maximum effort on the damped and non-damped bike with vibration was measured. The intensity of efforts is based on the loading structure of a cycle race with a large proportion of close to threshold phases and short high intensity efforts (Sanders & Heijboer,2019). A two-way repeated-measures ANOVA identified the effects of vibration and bike damping. The study was approved by the ethics committee of the German Sport University Cologne and conformed to the principles of the World Medical Association Declaration of Helsinki. Supplementary data including local accelerations transferred to the body, cardiovascular and respiratoric measurments and performance testing has been published previously (Viellehner & Potthast, 2019).

Results: With the presence of vibration, muscular activation of gastrocnemius lateralis, soleus and triceps brachii increased significantly, compared to the NoVib condition. No vibration effect was observed for vastus lateralis and rectus femoris. Damping reduced the activation of triceps brachii during vibration significantly. The mean cranking power of the 20-second maximum efforts with vibration was comparable for Damp and NoDamp (Tab. 1).

Discussion: Vibration increased neuromuscular demands partially. While the activation of distal muscles with high vibration exposure (Viellehner & Potthast, 2018) like gastrocnemius lateralis and soleus increased, more proximal muscles such as vastus lateralis or rectus femoris were not affected by vibration. The joint power distribution of ankle-, knee-, and hip joint indicates that the muscles affiliated to the knee and hip, which showed no response to vibration, contribute the major part to propulsion (Mornieux et al., 2007; Zajac et al., 2002). Therefore, vibration does not significantly impair the propulsion generation. Bike damping did not affect the muscular activation of thigh and shank muscles. Accordingly, the power output of the 20 second maximum effort with vibration was comparable for the damped and non-damped bike. This is in line with previous findings, which demonstrate for a damped and non-damped bike a comparable power output during a maximum 4 minute effort with vibrations (Viellehner & Potthast, 2019). At the upper body, activation of the triceps brachii increased with vibration. With damping, this increase was less extensive. Data we published previously indicates, bike damping decreases effectively the vibration exposure at the upper body and arms, but not at the lower extremities (Viellehner & Potthast, 2018). A reduced muscular activation at the arms and an unchaged activation of the lower extremity muscles with damping therefore, possibly relates back to this vibration exposure. The only local damping effect on the comparably small arm muscles could also be an explanation why bike damping does not reduce the respiratory demand (Viellehner & Potthast, 2019), which increases slightly with vibration (Sperlich et al., 2009, Rønnestad et al., 2018).

Conclusions: Although roadbike damping reduced the activation of small muscle groups in the arms, damping did not change the mechanical stimulus and neuromuscular demands at the lower extremities. This may explain why damping did not reduce the respiratory demand or enhance power output during vibration. Therefore, damping does not influence short term performance, as in an isolated attacking situation on cobbles. The present approach focusses on short term neuromuscular performance. Considering the long race duration of a cobblestone classic of about 6 hours, it is reasonable to assume that especially fatigue-related aspects are an interesting research perspective.

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Table 1: Mean muscular activation and power-output for the damped and non-damped bike.
*** indicates significant increase with vib (Vib-NoVib) ($p< 0.05$), $^{\#}$ indicates significant decrease with damp (Damp–NoDamp) ($p< 0.05$)**

	Non-Damped		Damped	
	No-Vib	**Vib**	**No-Vib**	**Vib**
mean muscular activation [% peak-baseline]				
soleus	0.27 ± 0.06	0.39 ± 0.15*	0.26 ± 0.04	0.38 ± 0.10*
gast. lat.	0.33 ± 0.07	0.37 ± 0.07*	0.34 ± 0.05	0.38 ± 0.06*
vast. lat.	0.24 ± 0.03	0.25 ± 0.06	0.26 ± 0.04	0.26 ± 0.06
rec. fem.	0.32 ± 0.14	0.35 ± 0.19	0.31 ± 0.10	0.32 ± 0.12
triceps	0.68 ± 0.13	0.98 ± 0.23*	0.66 ± 0.10	0.78 ± 0.14*$^{\#}$
mechanical power [W/kg]				
20 s power		9.42 ± 1.1		9.6 ± 1.23

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