

Figure 1 The effects of norepinephrine (NE) on heart rate (HR) and contractile force (tension) in isolated atrial preparations of control (○), morphine-dependent (■) and morphine-withdrawal rats (▲). Values are mean ± SEM (n = 6). **P* < 0.05; ***P* < 0.01 compared with the control group.

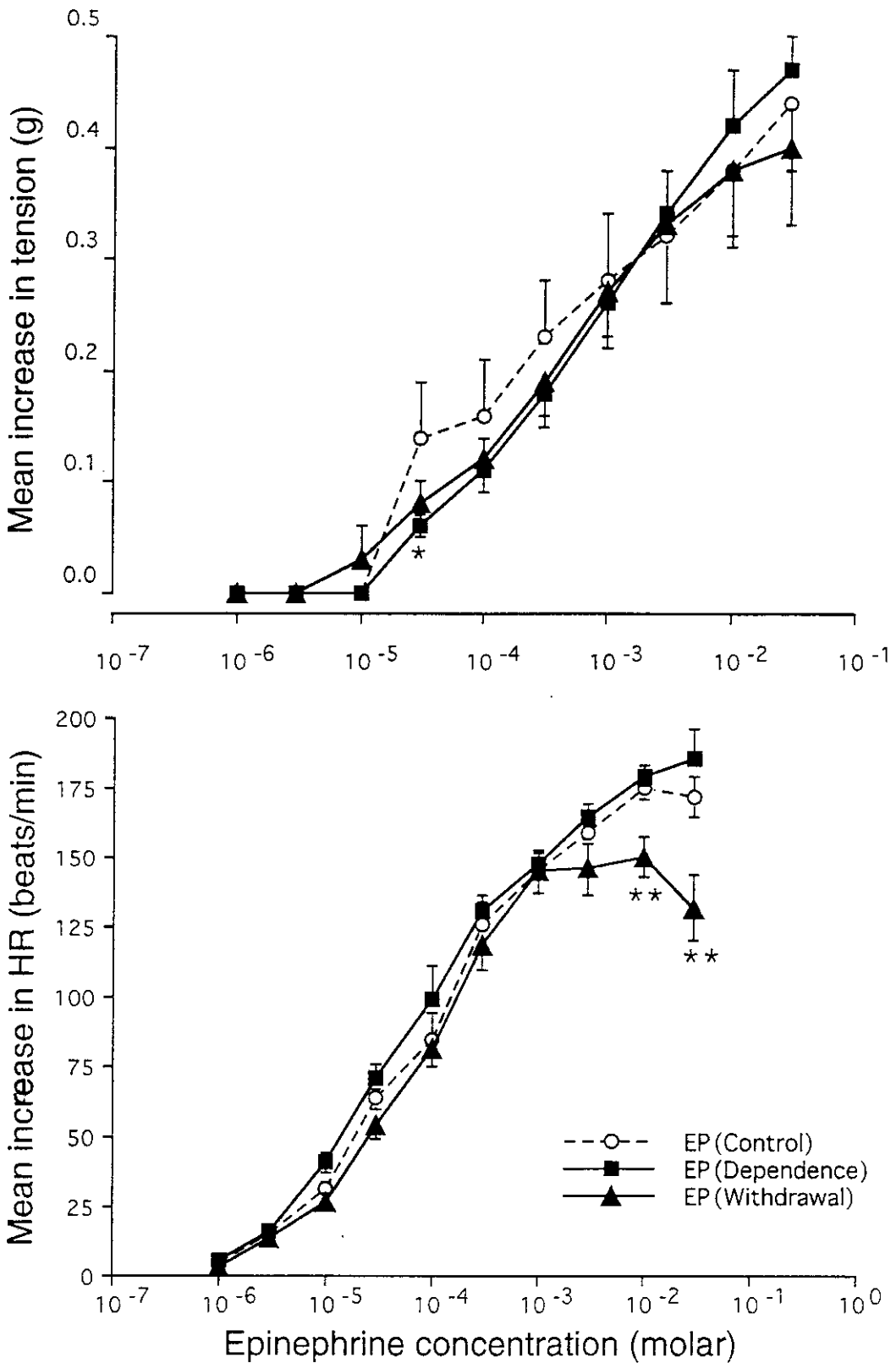


Figure 2 The effects of epinephrine (EP) on heart rate (HR) and contractile force (tension) in isolated atrial preparations of control (○), morphine-dependent (■) and morphine-withdrawal rats (▲). Values are mean \pm SEM (n = 6). * $P < 0.05$; ** $P < 0.01$ compared with the control group.

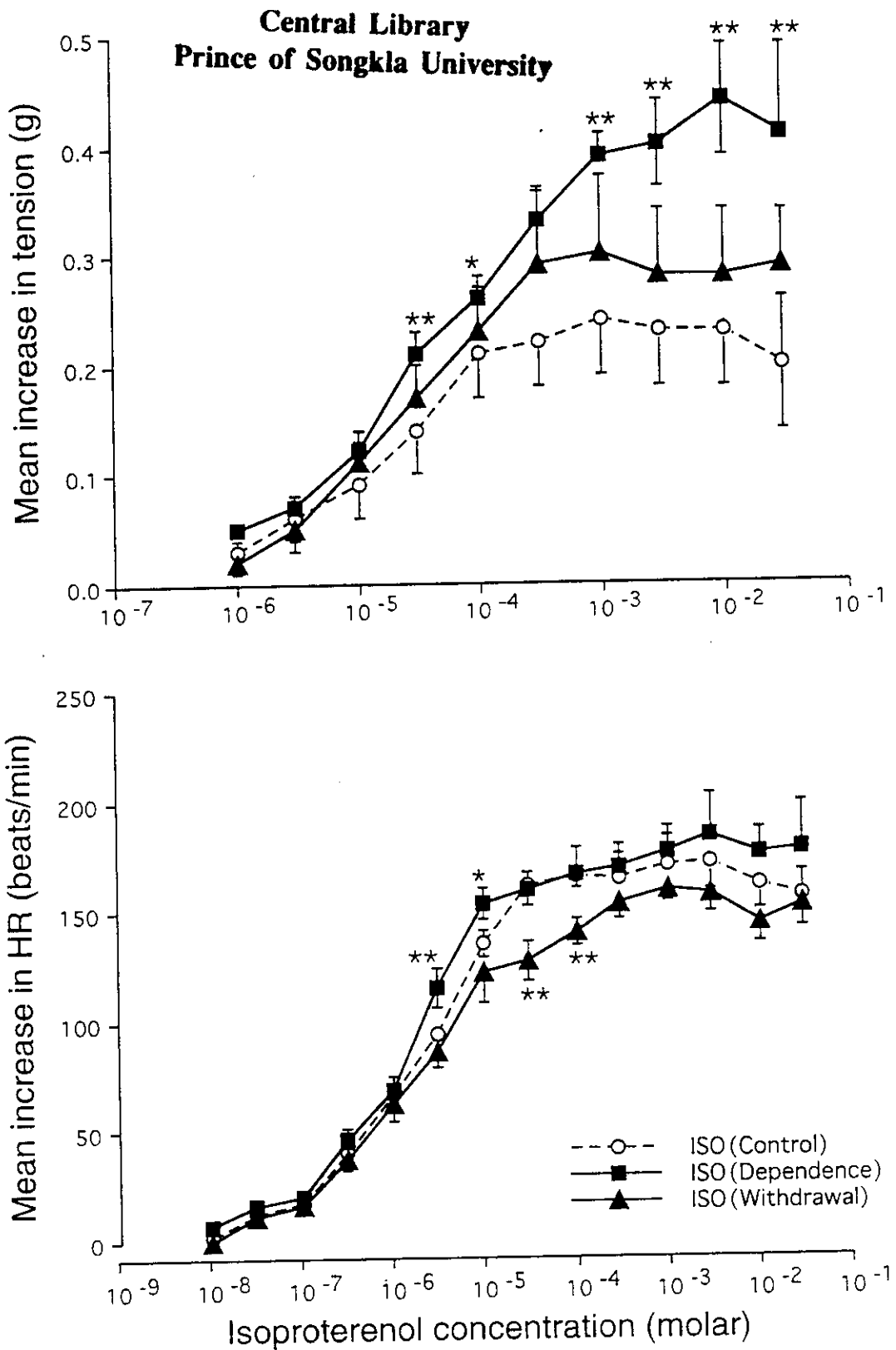


Figure 3 The effects of isoproterenol (ISO) on heart rate (HR) and contractile force (tension) in isolated atrial preparations of control (○), morphine-dependent (■) and morphine-withdrawal rats (▲). Values are mean \pm SEM (n = 6). * $P < 0.05$; ** $P < 0.01$ compared with the control group.

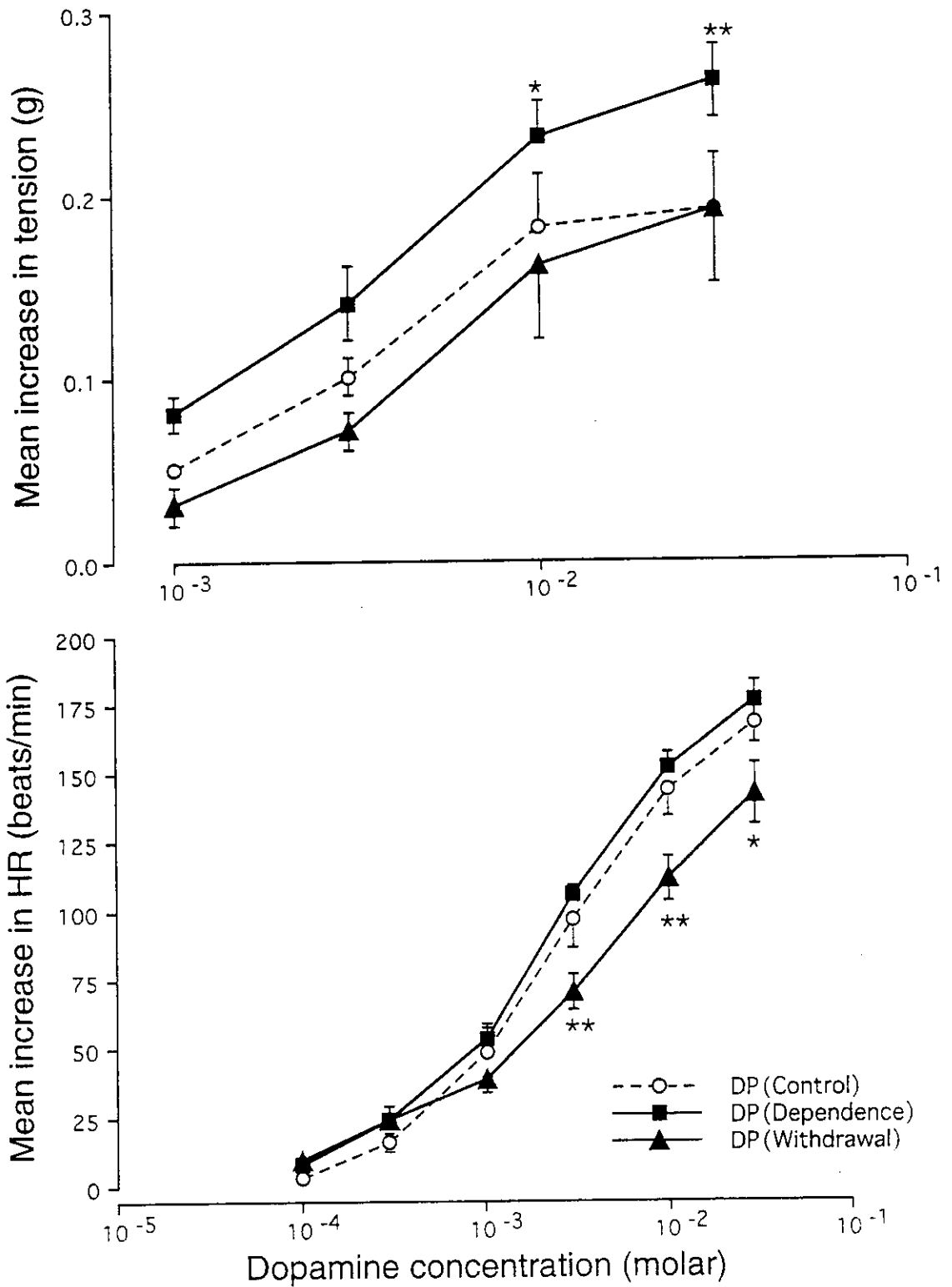


Figure 4 The effects of dopamine (DP) on heart rate (HR) and contractile force (tension) in isolated atrial preparations of control (○), morphine-dependent (■) and morphine-withdrawal rats (▲). Values are mean \pm SEM (n = 5 - 6). * $P < 0.05$; ** $P < 0.01$ compared with the control group.

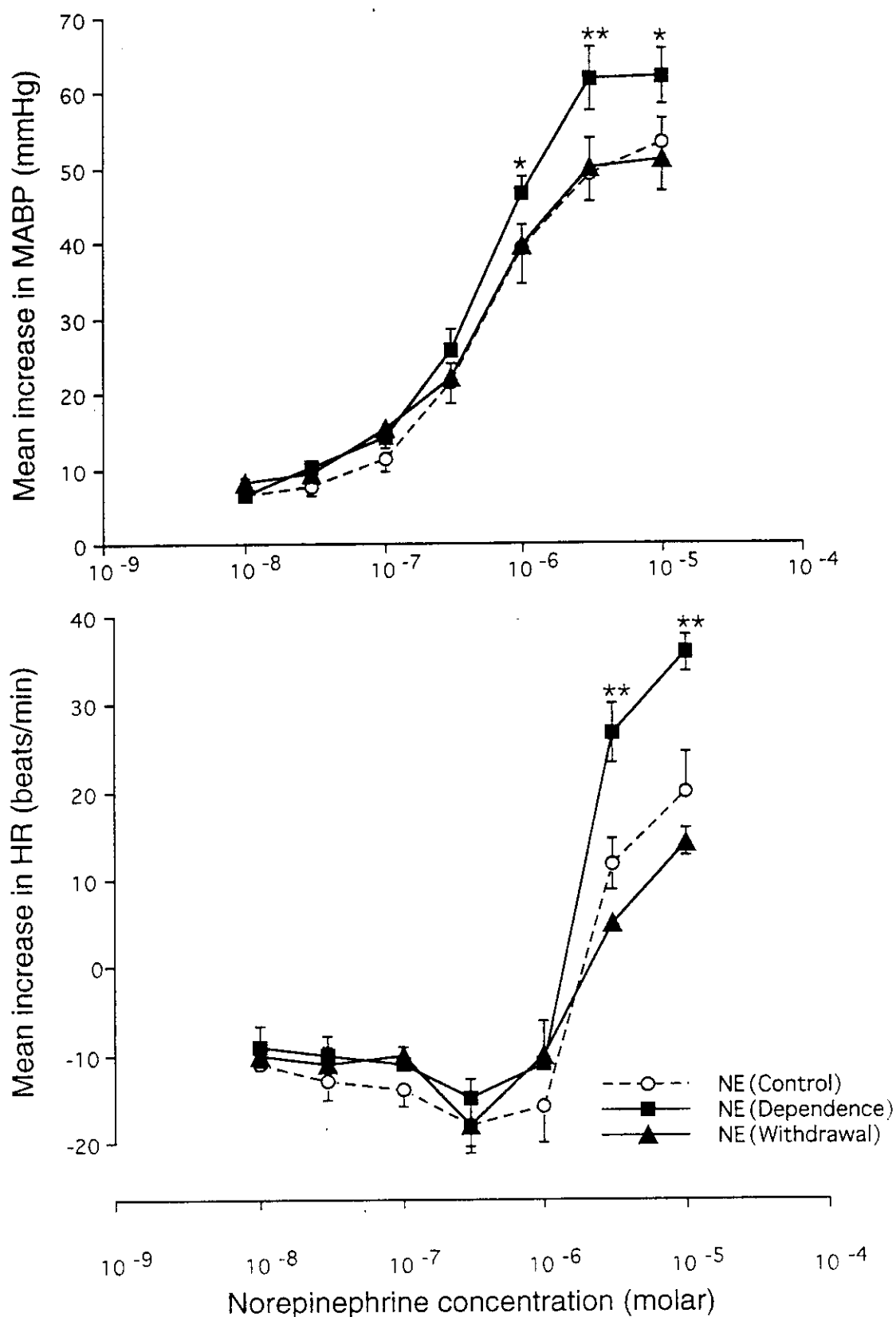


Figure 5 The effects of norepinephrine (NE) on heart rate (HR) and mean arterial blood pressure (MABP) in anesthetized rats of control (○), morphine-dependent (■) and morphine-withdrawal groups (▲). Values are mean \pm SEM (n = 6). * $P < 0.05$; ** $P < 0.01$ compared with the control group.

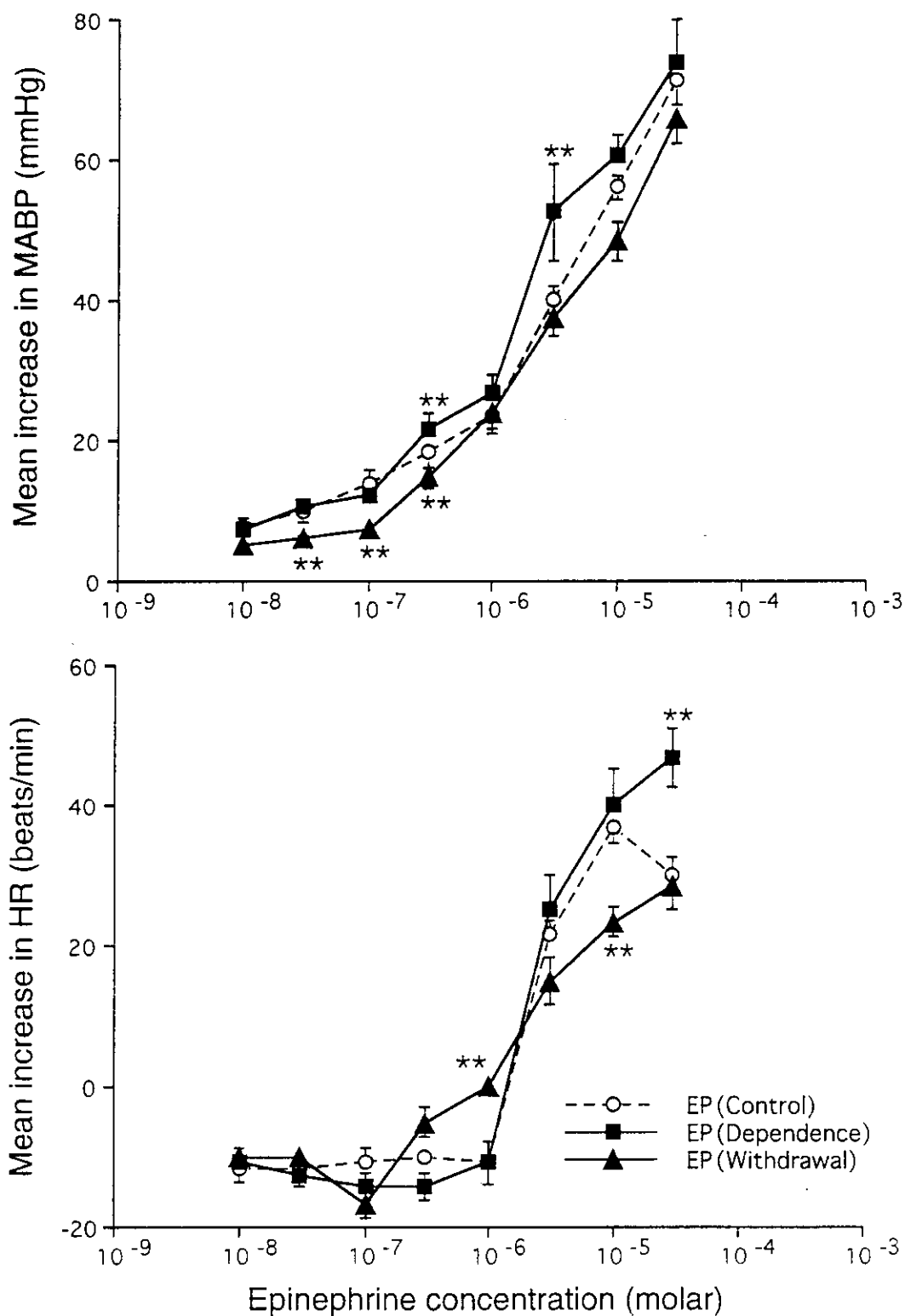


Figure 6 The effects of epinephrine (EP) on heart rate (HR) and mean arterial blood pressure (MABP) in anesthetized rats of control (○), morphine-dependent (■) and morphine-withdrawal groups (▲). Values are mean \pm SEM (n = 6). * $P < 0.05$; ** $P < 0.01$ compared with the control group.

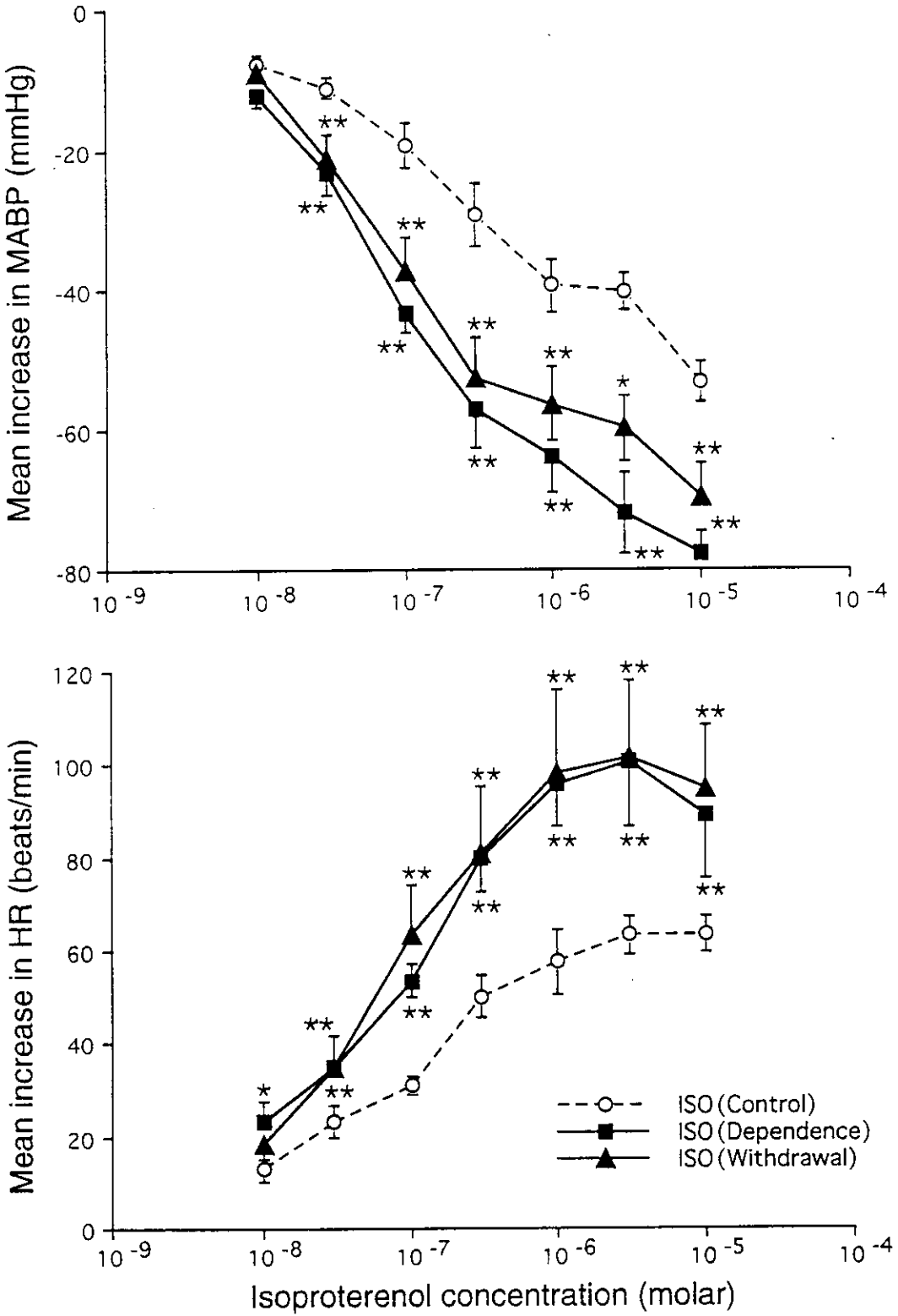


Figure 7 The effects of isoproterenol (ISO) on heart rate (HR) and mean arterial blood pressure (MABP) in anesthetized rats of control (○), morphine-dependent (■) and morphine-withdrawal groups (▲). Values are mean \pm SEM (n = 6). * $P < 0.05$; ** $P < 0.01$ compared with the control group.

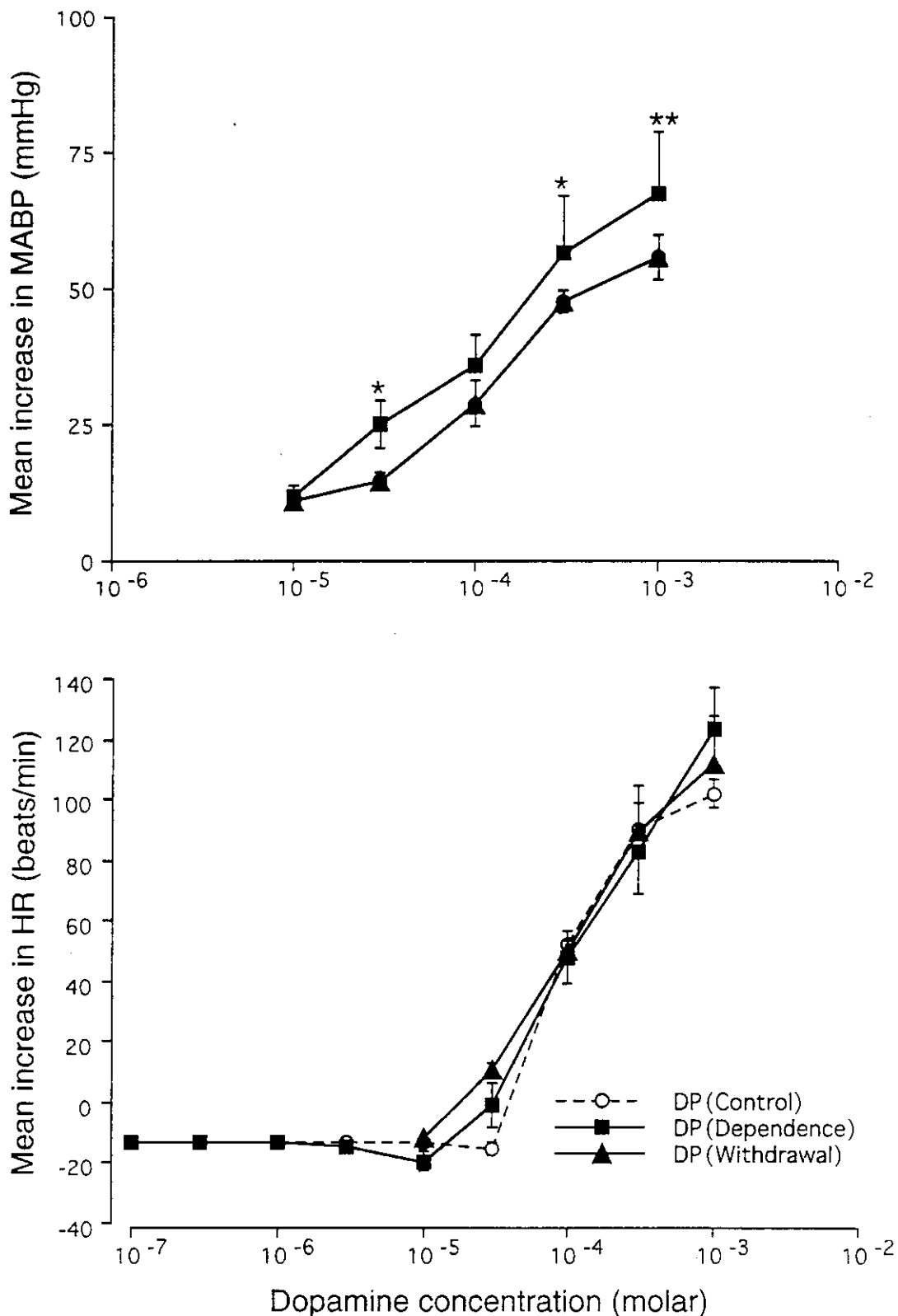


Figure 8 The effects of dopamine (DP) on heart rate (HR) and mean arterial blood pressure (MABP) in anesthetized rats of control (○), morphine-dependent (■) and morphine-withdrawal groups (▲). Values are mean \pm SEM (n = 6). * $P < 0.05$; ** $P < 0.01$ compared with the control group.

Table 1 Changes in maximum responses of heart rate, mean arterial blood pressure and contractile force (tension) to norepinephrine, epinephrine, isoproterenol and dopamine in isolated rat atrial preparations and anesthetized rats of morphine-treated and morphine-withdrawal groups compared with the control group.

Changes in maximum responses (mean \pm SEM)				
Drugs	Isolated rat atria		Anesthetized rats	
	HR (beats min ⁻¹)	Tension (g)	HR (beats min ⁻¹)	MABP (mmHg)
Norepinephrine				
Control	+174.2 \pm 6.3	+0.37 \pm 0.03	+20.0 \pm 4.5	+53.3 \pm 3.1
Dependence	+175.0 \pm 8.5	+0.55 \pm 0.09**	+35.8 \pm 2.0**	+62.0 \pm 3.7*
Withdrawal	+158.3 \pm 11.2*	+0.40 \pm 0.04	+14.2 \pm 1.5	+51.2 \pm 4.3
Epinephrine				
Control	+175.0 \pm 4.1	+0.44 \pm 0.06	+36.7 \pm 2.1	+71.2 \pm 3.5
Dependence	+179.2 \pm 3.5	+0.47 \pm 0.03	+46.7 \pm 4.2**	+73.8 \pm 6.1
Withdrawal	+150.0 \pm 7.2**	+0.40 \pm 0.07	+28.3 \pm 3.1**	+65.8 \pm 3.5
Isoproterenol				
Control	+171.7 \pm 12.8	+0.24 \pm 0.05	+63.3 \pm 4.2	-53.2 \pm 2.9
Dependence	+183.3 \pm 19.8	+0.44 \pm 0.05**	+100.8 \pm 17.1**	-77.8 \pm 3.2**
Withdrawal	+159.2 \pm 4.5	+0.30 \pm 0.07	+101.7 \pm 14.9**	-69.7 \pm 4.7**
Dopamine				
Control	+167.5 \pm 7.2	+0.18 \pm 0.04	+103.3 \pm 4.9	+55.8 \pm 4.0
Dependence	+175.8 \pm 7.2	+0.25 \pm 0.02**	+125.0 \pm 13.6	+67.5 \pm 4.6**
Withdrawal	+142.0 \pm 11.3*	+0.18 \pm 0.03	+113.3 \pm 15.6	+62.5 \pm 3.8

HR, Heart rate; MABP, mean arterial blood pressure; SEM, standard error of means.

+, Increase; -, decrease. * $P < 0.05$; ** $P < 0.01$ compared with the control group.