EFFECTS OF RESISTANCE ON 3D FORCE APPLICATION DURING LOW-INTENSITY HANDCYCLING IN HEALTHY MEN

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Introduction

Since the eighties of last century, handcycling has become an important alternative to hand-rim propulsion for wheelchair users [1, 2]. Even nowadays, little is known about the force application on the handles in daily use of the handcycle. The aim of our study was to investigate the effects of resistance on the 3D force application on the handlebar during low-intensity synchronous handcycling. Since people prefer a higher cadence [3], we expect that force effectiveness is higher when handcycling with a lower resistance.

Methods

Twelve non-disabled healthy men (age: 23.9±1.2 [yrs.], mass: 78.6±9.1 [kg], length: 1.81±0.05 [m] and arm length: 0.64±0.02 [m]) rode in an instrumented handcycle [4] with a synchronous crank setting on a level motorized treadmill at 1.94 m/s in nine different resistance conditions. We changed the resistance by either changing the gear or increasing the power output (by adding weight to a pulley system attached to the back of the handcycle). The participants handcycled on three different occasions, with two days rest in-between. We changed the power output (+ 0, + 10, and + 20 [W]) between session. Every session consisted of three blocks of four minutes of exercise. Every block we changed the gear (1≈70 [rpm], 2≈60 [rpm], and 3≈52 [rpm]). 3D forces were continuously measured at the left handlebar. We analyzed only the last minute of every four-minute bout to ensure a steady state was reached. Over this last minute, we calculated the mean force for every full cycle. From the measured forces, we calculated the fraction of effective force (FEF [%]), and subsequently the mean value. We analyzed the effects of resistance with a repeated measures ANOVA (P<0.05) with gear and power output as within-subject factors.

$$FEF\ [\%] = (F_{tan}/F_{resultant})*100\%$$

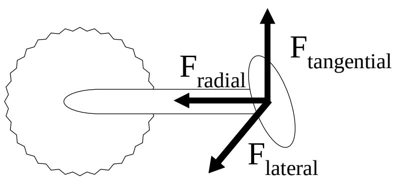

Figure 1: Definition coordinate system in the left handlebar of crank system (rotation counterclockwise)

Results

The mean forces are presented in table 1. We found a significant effect of gear on FEF (P<0.001, η^2_p=0.79) as well as on all force components (F_{tan}: P<0.001, η^2_p=0.93; F_{rad}: P=0.001, η^2_p=0.49; F_{lat}: P=0.046, η^2_p=0.27). Added power had a significant effect on FEF (P<0.001, η^2_p=0.56), F_{tan} (P<0.001, η^2_p=0.98), and F_{rad} (P=0.046, η^2_p=0.31), but not on F_{lat} (P=0.143, η^2_p=0.18). For F_{tan} we also found an interaction effect (P<0.001, η^2_p=0.72).

Discussion

With an increase in resistance, by either changing the gear or adding power output, we found an increase in effective force propulsion during low-intensity handcycling. Based on low-intensity handcycling, we suggest that a somewhat higher overall resistance setting beneficially affects force effectiveness. Yet effects on internal musculoskeletal loading remain uncertain.

n = 11		FEF [%]	F_{tan} [N]	F_{rad} [N]	F_{lat} [N]
Gear 1: 69±2 [rpm]	+ 0 [W]	53.0 ±11.1	6.4 ±1.6	-2.2 ±1.4	-1.0 ±1.7
	+ 10 [W]	59.0 ±13.6	10.5 ±1.3	-0.6 ±2.2	-1.8 ±1.7
	+ 20 [W]	62.1 ±10.8	13.5 ±1.3	0.5 ±2.2†	-2.2 ±1.8
Gear 2: 59±1 [rpm]	+ 0 [W]	60.2 ±10.7	7.5 ±1.5	-0.9 ±1.0	-0.7 ±1.6
	+ 10 [W]	67.4 ±11.9	11.9 ±2.0	0.4 ±1.9	-2.4 ±2.0
	+ 20 [W]	70.5 ±9.5	16.4 ±1.4	1.4 ±3.0	-2.1 ±2.6
Gear 3: 52±1 [rpm]	+ 0 [W]	63.9 ±9.1	8.3 ±1.4	0.2 ±1.2	-1.4 ±2.0
	+ 10 [W]	71.9 ±10.4	13.6 ±2.2	0.8 ±1.7	-2.7 ±2.4
	+ 20 [W]	78.1 ±6.3	19.4 ±2.3	0.9 ±3.4	-3.2 ±3.1

Table 1: Mean ± SD of the 3D force components
†Not normally distributed

References

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