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Section II - Exercise Physiology & Sports Medicine

Cardiorespiratory, Metabolic and Perceived Responses to Electrical Stimulation of Upper-Body Muscles While Performing Arm Cycling

by
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This study was designed to assess systemic cardio-respiratory, metabolic and perceived responses to incremental arm cycling with concurrent electrical myostimulation (EMS). Eleven participants (24 ± 3 yrs; 182 ± 10 cm; 86 ± 16.8 kg) performed two incremental tests involving arm cycling until volitional exhaustion was reached with and without EMS of upper-body muscles. The peak power output was 10.1% lower during arm cycling with (128 ± 30 W) than without EMS (141 ± 25 W, p = 0.01; d = 0.47). In addition, the heart rate (2-9%), oxygen uptake (7-15%), blood lactate concentration (8-46%) and ratings of perceived exertion (4-14%) while performing submaximal arm cycling with EMS were all higher with than without EMS (all $p < 0.05$). Upon exhaustion, the heart rate, oxygen uptake, lactate concentration, and ratings of perceived exertion did not differ between the two conditions (all $p > 0.05$). In conclusion, arm cycling with EMS induced more pronounced cardio-respiratory, metabolic and perceived responses, especially during submaximal arm cycling. This form of exercise with stimulation might be beneficial for a variety of athletes competing in sports involving considerable generation of work by the upper body (e.g., kayaking, cross-country skiing, swimming, rowing and various parasports).

Key words: *arm cycling, oxygen uptake, parasports, ratings of perceived exertion, upper body.*

Introduction

Leg cycling, which involves all muscles of the lower body, is probably most commonly used to characterize various cardiorespiratory, metabolic and perceived responses to exercise. In contrast, far less is known about arm cycling (Secher et al., 1974), which is surprising since many individuals perform upper-body exercise, including competitive athletes (cross-country skiers, swimmers, rowers, kayakers, and those competing in various racket and combat sports, certain team sports and Paralympic events, etc.), as well as individuals with lower-body paralysis.

In general, the upper-body contains less muscle and performs less work than the legs, e.g., the heart rate (HR) is higher and stroke volume lower during submaximal upper-body than leg exercise (Calbet et al., 2015; Miles et al., 1989). Most muscle groups of the upper-body comprise a greater relative amount of type II muscle fibers than those of the legs (Koppo et al., 2002; Sanchis-Moysi et al., 2010; Zinner et al., 2016), which results in distinct differences in the physiological responses of the arms and legs to exercise (Secher et al., 1974; Zinner et al., 2016).

In a recent investigation, while performing leg-cycling, the muscles involved were subjected to, e.g., electrical stimulation (Wahl et al., 2012), plantar vibration (Suhr et al., 2007) and blood flow restriction (Thomas et al.,

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2018) to increase the work load and the acute cardiorespiratory, metabolic and perceived responses compared to those during leg-cycling without stimulation. Far less is presently known about the effects of concurrent stimulation, in particular electrical stimulation, on acute cardiorespiratory, metabolic and perceived responses during arm cycling.

To improve performance and/or health, as well as to recover from injury, exercise with concurrent whole-body electrical myostimulation (EMS) has been adopted by a wide spectrum of individuals, ranging from elite and recreational athletes to patients. Exercise with concurrent EMS improved athletic performance (e.g., maximal strength; Brocherie et al., 2005), as well as general fitness (e.g., increased power output and peak oxygen uptake; Kemmler et al., 2018). One underlying mechanism proposed involves the greater number of motor units recruited with concurrent EMS (Salmons, 2009). This recruitment is non-selective, synchronous and localized, i.e., during exercise with EMS both type I and type II muscle fibers are recruited simultaneously and immediately at the onset of exercise, even at low intensities (Gregory and Bickel, 2005; Nosaka et al., 2011), which makes this approach especially interesting in connection with submaximal exercise. In addition, the benefits of exercise on metabolic health depend on the amount of muscle mass involved and since EMS training activates more muscle mass, co-activating both the agonist and antagonist muscles simultaneously, this form of exercise appears to elevate metabolic demands efficiently.

Previous findings indicate that addition of EMS to endurance cycling may enhance the stimulation of skeletal muscle, with augmented cardiovascular stress. Whereas several studies have explored acute responses to endurance leg exercise with EMS (Kim Takala et al., 1995; Pano-Rodriguez et al., 2019), none have investigated these in connection with arm exercise. Clearly, before a new form of training can be recommended its acute effect must be understood in some detail.

Therefore, the current study was designed to assess the systemic cardio-respiratory, metabolic and perceived responses to incremental arm cycling with concurrent EMS. Since addition of EMS activates more motor units at any given intensity, we hypothesized that the cardio-respiratory, metabolic and perceived responses would be more pronounced with than without EMS.

Methods

Participants

The 11 healthy participants (age: 24 ± 3 yrs; body height: 182 ± 10 cm; body mass: 86 ± 16.8 kg; percentage body fat mass: 14.0 ± 3.7 %; means ± SD) all exercised recreationally (jogging, cycling, etc.) one to three times a week, although none trained regularly for any particular sporting event. All had extensive experience with the laboratory procedures employed. Each participant was informed in detail about the test protocols before providing written consent to participate. All procedures were pre-approved by the local ethics committee and conducted in accordance with the Declaration of Helsinki.

Design and Procedures

During the first visit to the laboratory, anthropometric data were collected. During the second and third visits, which were 7 days apart, all participants performed an incremental arm-cycling test, either with or without concurrent EMS, in randomized order.

This incremental test consisted of 3 min of sitting (without EMS and with the arms still) on the ergometer, during which time baseline values were obtained. After sitting for additional 3 min on the ergometer with EMS of the upper-body muscles, but still with no arm movement, another set of values was obtained. Thereafter, incremental testing commenced at an initial workload of 40 W, with a 20-W increase every 3 min until volitional exhaustion. The arm cycle ergometer (Monark 891E cycle ergometer) was mounted on an adjustable stand (Monark Exercise AB, Vansbro, Sweden) and associated Monark software monitored power output during the entire trial. The settings for the ergometer (seat height, distance of the upper body to the center of the arm cranks) were adjusted individually as described previously (Brink-Elfegoun et al., 2007) during the first visit and employed thereafter.

The EMS device (miha bodytec, Emersacker, Germany) was attached to both upper arms, the upper and lower back, chest, and stomach and the following settings were utilized: bipolar impulse frequency, 85 Hz; impulse width, 400 ms; time on, 10 s; time off, 2 s. The intensity was set individually at the maximum tolerated in terms of discomfort and the ability to continue arm cycling in a proper manner.

Oxygen uptake was monitored continuously with an open-circuit breath-by-breath gas analyzer (MetaMax 3B, Cortex Biophysik, Leipzig, Germany), employing standard algorithms to compensate for the time delay between gas consumption and the signal. The oxygen sensor was calibrated prior to each test with both 15.8% and 5% O_2 in N_2 (Praxair, Düsseldorf, Germany), i.e., concentrations that cover the range of the expected fractional concentration of O_2. The volume sensor was calibrated with a precision 3-L syringe (Cortex Biophysik, Leipzig, Germany). Average 30-s respiratory values were calculated and oxygen uptake during the final 30 s of the step test defined as peak oxygen uptake (VO_{2peak}). The respiratory exchange ratio was calculated by dividing carbon dioxide production by oxygen uptake.

Blood for analysis of lactate concentration was sampled from the right earlobe (Lactate Scout, EKF-diagnostics GmbH, Germany) at baseline, following 3 min of sitting with or without EMS, and after each 3-min step during the incremental test.

At the same time-points, all participants rated their perceived exertion (RPE) employing the Borg's 6-20 scale (Borg, 1970).

Statistical Analysis

Appropriate analysis revealed that all data were normally distributed, with no further transformation required. The effect size, Cohen's *d* (Cohen, 1988), was calculated for all variables, with the thresholds for small, moderate, and large effects being set at 0.20, 0.50, and 0.80, respectively (Cohen, 1988). A paired Student's t-test was applied to compare peak power outputs and repeated-measures ANOVA to compare all other variables between trials. When a global difference over time was indicated, Tukey post-hoc analysis was employed to determine when the change occurred. *p*-value ≤ 0.05 was considered statistically significant and all analyses were carried out using the Statistica software package for Windows® (version 7.1, StatSoft Inc., Tulsa, OK, USA).

Results

Table 1 documents the blood lactate concentration, heart rate, oxygen uptake, respiratory exchange ratio, and ratings of perceived exertion associated with each step of the incremental test.

The mean peak power output was (10.1%) lower during arm cycling with (128 ± 30 W) than without EMS (141 ± 25 W, $p = 0.01$; d = 0.47).

During the submaximal steps, the values for the heart rate (2-9%), levels of blood lactate (8-46%), and ratings of perceived exertion (4-14%) were higher during arm cycling with EMS, with small to high effect sizes (d = 0.22 – 1.26), with occasional statistical significance (Table 1). Oxygen uptake was significantly higher during the 100, 120, and 140 W steps with than without EMS (+7-15%, all $p < 0.05$).

However, at exhaustion, the heart rate, oxygen uptake, lactate, and ratings of perceived exertion did not differ between the two conditions (all $p > 0.05$).

Discussion

This study was designed to assess the systemic cardio-respiratory, metabolic and perceived responses to incremental arm cycling with concurrent EMS. Our major findings were as follows:

i) submaximal responses with respect to the heart rate (2-9%), oxygen uptake (7-15%), blood lactate concentration (8-46%) and ratings of perceived exertion (4-14%) were all higher with than without EMS;

ii) when voluntary exhaustion was reached, these responses did not differ between the two conditions.

During the incremental test, participants demonstrated 10.1% lower peak power output during arm cycling with than without EMS, despite displaying in both trials mean maximal heart rates > 220-age, with levels of blood lactate >10 mmol/L, and a respiratory exchange ratio > 1.1 , as well as scoring 20.0 on the Borg's scale, indicating physical exhaustion in connection with both trials. Potential explanations for the more pronounced responses with concurrent electric myostimulation include the following.

Usually during low-intensity exercise, only small motor units are recruited, activating fatigue-resistant type I fibers, while with increasing exercise intensity, larger motor units containing stronger type II fibers are activated (Henneman et al., 1965). However, EMS activates both type I and type II fibers non-selectively even at low intensities (Gregory and Bickel, 2005). During leg cycling with concurrent EMS, this more extensive recruitment of type II fibers elevates the metabolic demands (as indicated by higher blood lactate concentrations, a base excess, and altered substrate utilization) compared to conventional cycling, thereby causing fatigue earlier (Wahl et al., 2012).

Table 1

*Cardiorespiratory, metabolic and perceived variables during an incremental arm-cycling test with and without concurrent electrical myostimulation (EMS) of the upper body. * = $p < 0.05$*

Variable	Trial	Statistics	Baseline		Incremental increases in power output [W]						
			with EMS	without EMS	40 (n=11)	60 (n=11)	80 (n=11)	100 (n=11)	120 (n=8)	140 (n=8)	Maximal (n=11)
Blood lactate [mmol/L]	without EMS		n.d.	1.5±0.2	2.2±0.8	2.7±0.9	3.5±1.2	5.1±1.7	6.5±1.9	7.6±1.7	10.4±2.1
	with EMS		1.5±0.4	1.3±0.3	2.6±0.6	3.4±1.0	4.5±1.8	5.5±2.0	8.0±2.7	11.1±4.9	11.7±3.9
		Δ%		-15	+18	+26	+29	+8	+23	+46	+13
		Cohen's d		0.58	0.56	0.70	0.61	0.22	0.61	0.94	0.42
		P-value		1.00	1.00	1.00	1.00	1.00	0.93	0.001*	0.41
Heart rate [bpm]	without EMS		n.d.	81±10	107±17	118±20	131±22	152±21	160±17	169±11	178±9
	with EMS		80±15	77±14	111±21	128±25	142±23	157±22	169±19	173±18	177±11
		Δ%		-5	+4	+9	+8	+3	+6	+2	-1
		Cohen's d		0.34	0.23	0.42	0.46	0.23	0.56	0.26	0.13
		P-value		0.92	0.74	0.84	0.15	0.14	0.02*	0.97	1.00
Oxygen uptake [ml/min]	without EMS		n.d	0.41±0.06	0.99±0.14	1.24±0.13	1.52±0.13	2.01±0.26	2.30±0.20	2.76±0.20	2.93±0.46
	with EMS		0.45±0.09	0.40±0.11	1.13±0.09	1.43±0.21	1.72±0.19	2.15±0.26	2.58±0.29	3.05±0.38	2.91±0.74
	Δ%	Δ%		-2	+14	+15	+13	+7	+12	+11	+1
	Cohen's d	Cohen's d		0.04	1.13	1.07	1.26	0.55	1.12	0.97	0.04
	p-value	P-value		1.00	0.61	0.08	0.12	0.05*	0.04*	0.01*	1.00
Respiratory exchange ration [a.u.]	without EMS		n.d.	0.89±0.07	0.91±0.06	0.93±0.06	0.96±0.07	1.02±0.09	1.02±0.06	1.07±0.06	1.12±0.04
	with EMS		0.87±0.04	0.85±0.05	0.92±0.05	0.94±0.05	0.98±0.08	1.00±0.06	1.03±0.06	1.05±0.04	1.09±0.04
		Δ%		-5	+1	+1	+2	2	1	-2	-3
		Cohen's d		0.50	0.18	0.12	0.32	0.35	0.24	0.23	0.69
		P-value		0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ratings of perceived exertion [a.u.]	without EMS		n.d.	6.0±0.0	8.6±1.7	10.8±1.2	13.3±1.7	15.8±2.5	16.8±1.7	18.6±1.3	19.9±0.3
	with EMS		6.0±0.0	6.0±0.0	9.7±2.4	12.3±2.2	14.4±2.8	16.6±2.2	17.7±1.6	19.3±0.8	20.0±0.0
		Δ%		0	+13	+14	+8	+5	+5	+4	+1
		Cohen's d		0	0.52	0.88	0.47	0.33	0.59	0.62	0.25
		P-value		1.00	0.61	0.82	0.61	0.39	0.22	0.61	1.00

a.u. = arbitrary units; n.d. = not determined

Compared to the legs, upper-body muscles contain a greater proportion of type II fibers (Koppo et al., 2002; Sanchis-Moysi et al., 2010; Zinner et al., 2016), which results in earlier activation of such fibers even without EMS. Thus, it may be predicted that concurrent EMS during arm exercise would not induce more pronounced responses, but that was not the case here.

Inexperienced individuals performing upper-body exercise rely more on the glycolytic pathway than when performing leg exercise, even in the absence of EMS (Zinner et al., 2016). Furthermore, vascular reactivity differs between the arms and the legs. In the arms, greater changes in the blood flow in response to a physiological vasodilatory stimulus occur

(Richardson et al., 2006). Furthermore, a higher cardiovascular effort is necessary to maintain a given metabolic rate in the upper limbs compared to the lower limbs, which is due to the lower capacity and efficiency of the arms to extract O_2 from the blood (Calbet et al., 2005). For this reason, higher glycolytic demands during arm cranking even without EMS are to be expected. Since the uptake and the subsequent oxidation of lactate by the legs is strongly correlated with lactate delivery and an elevated metabolic rate, lactate produced during arm cranking is immediately utilized in the legs (Van Hall et al., 2003). Earlier it has been shown that compared to voluntary contraction, specific EMS of the quadriceps muscle during incremental tests of one-legged dynamic knee extension leads to higher metabolic demands (i.e., a higher HR and mean arterial pressure) (Kim Strange et al., 1995). All the aforementioned reasons may explain statistical differences were not detected in the measurements of blood lactate between the EMS and without-EMS intervention even though the lactate concentration was 8-46% greater during EMS.

In contrast to previous reports (Wahl et al., 2012), we observed no difference in the respiratory exchange ratio, an indicator of lipid oxidation, glycogenolysis and glycolysis (Bergman and Brooks, 1999; Brooks, 1997; Dudley et al., 1987; Jansson and Kaijser, 1987), while arm cycling with or without EMS. One possible explanation for this discrepancy is that the small muscle mass in the upper-body of our participants did not influence such systemic variables, but that fatigue nevertheless occurred earlier with EMS. On the basis of our present findings, we conclude that cycling with and without EMS involves utilization of the same type of substrates.

The elevated ratings of perceived exertion observed here are consistent with our findings of elevated cardiorespiratory and metabolic responses during arm cycling with, rather than without EMS. Elevated ratings of perceived exertion during leg cycling with than without EMS have also been reported by others (Wahl et al., 2014).

Practical implications

Depending on the conditions and sport, arm cycling as an exercise is interesting from two perspectives. First, a variety of sports involve generation of considerable work by the upper body (e.g., many Paralympic sports, kayaking, cross-country skiing, swimming, rowing, etc.). Second, when leg training is not possible (e.g., due to injury), high-intensity interval training that engages upper-body muscles (Wingate anaerobic tests) enhances aerobic capacity (VO_{2peak}, mean power in time-trial) substantially (9%) within a relatively short period of time (6 sessions over 11 days) as we had demonstrated previously (Zinner et al., 2016). Moreover, when leg muscles become fatigued due to extensive training, arm cycling offers an effective alternative for stimulating the cardiovascular system further while allowing the legs to recover.

Conclusions

In conclusion, concurrent EMS during arm cycling enhanced the cardio-respiratory, metabolic and perceived responses, especially during submaximal arm cycling. This type of exercise could be beneficial to competitors in a variety of sports that involve performance of considerable work by the upper body (e.g., kayaking, cross-country skiing, swimming, rowing and various parasports), as well as for injured individuals. At the same time, chronic adaptation to this type of exercise remains to be characterized.

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References

Bergman BC, Brooks GA. Respiratory gas-exchange ratios during graded exercise in fed and fasted trained and untrained men. *J Appl Physiol,* 1999; 86: 479-487

Borg G. Perceived exertion as an indicator of somatic stress. *Scand J Rehabil Med,* 1970; 2: 92-98

Brink-Elfegoun T, Holmberg HC, Ekblom MN, Ekblom B. Neuromuscular and circulatory adaptation during combined arm and leg exercise with different maximal work loads. *Eur J Appl Physiol,* 2007; 101: 603-611

Brocherie F, Babault N, Cometti G, Maffiuletti N, Chatard JC. Electrostimulation training effects on the physical performance of ice hockey players. *Med Sci Sports Exerc,* 2005; 37: 455-460

Brooks GA. Importance of the 'crossover' concept in exercise metabolism. *Clin Exp Pharmacol Physiol,* 1997; 24: 889-895

Calbet JA, Gonzalez-Alonso J, Helge JW, Sondergaard H, Munch-Andersen T, Saltin B, Boushel R. Central and peripheral hemodynamics in exercising humans: leg vs arm exercise. *Scand J Med Sci Sports,* 2015; 25: 144-157

Calbet JA, Holmberg HC, Rosdahl H, van Hall G, Jensen-Urstad M, Saltin B. Why do arms extract less oxygen than legs during exercise? *Am J Physiol Regul Integr Comp Physiol,* 2005; 289: R1448-1458

Cohen D. *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates; 1988

Dudley GA, Tullson PC, Terjung RL. Influence of mitochondrial content on the sensitivity of respiratory control. *J Biol Chem,* 1987; 262): 9109-9114

Gregory CM, Bickel CS. Recruitment patterns in human skeletal muscle during electrical stimulation. *Phys Ther,* 2005; 85: 358-364

Henneman E, Somjen G, Carpenter DO. Functional Significance of Cell Size in Spinal Motoneurons. *J Neurophysiol,* 1965; 28: 560-580

Jansson E, Kaijser L. Substrate utilization and enzymes in skeletal muscle of extremely endurance-trained men. *J Appl Physiol,* 1987; 62: 999-1005

Kemmler W, Weissenfels A, Willert S, Shojaa M, von Stengel S, Filipovic A, Kleinoder H, Berger J, Frohlich M. Efficacy and Safety of Low Frequency Whole-Body Electromyostimulation (WB-EMS) to Improve Health-Related Outcomes in Non-athletic Adults. A Systematic Review. *Front Physiol,* 2018; 9: 573

Kim CK, Strange S, Bangsbo J, Saltin B. Skeletal muscle perfusion in electrically induced dynamic exercise in humans. *Acta Physiol Scand,* 1995; 153: 279-287

Kim CK, Takala TE, Seger J, Karpakka J. Training effects of electrically induced dynamic contractions in human quadriceps muscle. *Aviat Space Environ Med,* 1995; 66: 251-255

Koppo K, Bouckaert J, Jones AM. Oxygen uptake kinetics during high-intensity arm and leg exercise. *Respir Physiol Neurobiol,* 2002; 133: 241-250

Miles DS, Cox MH, Bomze JP. Cardiovascular responses to upper body exercise in normals and cardiac patients. *Med Sci Sports Exerc,* 1989; 21: S126-131

Nosaka K, Aldayel A, Jubeau M, Chen TC. Muscle damage induced by electrical stimulation. *Eur J Appl Physiol,* 2011; 111: 2427-2437

Pano-Rodriguez A, Beltran-Garrido JV, Hernandez-Gonzalez V, Reverter-Masia J. Effects of whole-body ELECTROMYOSTIMULATION on health and performance: a systematic review. *BMC Complement Altern Med,* 2019; 19: 87

Richardson RS, Secher NH, Tschakovsky ME, Proctor DN, Wray DW. Metabolic and vascular limb differences affected by exercise, gender, age, and disease. *Med Sci Sports Exerc,* 2006; 38: 1792-1796

Salmons S. Adaptive change in electrically stimulated muscle: a framework for the design of clinical protocols. *Muscle Nerve,* 2009; 40: 918-935

Sanchis-Moysi J, Idoate F, Olmedillas H, Guadalupe-Grau A, Alayon S, Carreras A, Dorado C, Calbet JA. The upper extremity of the professional tennis player: muscle volumes, fiber-type distribution and muscle strength. *Scand J Med Sci Sports,* 2010; 20: 524-534

Secher NH, Ruberg-Larsen N, Binkhorst RA, Bonde-Petersen F. Maximal oxygen uptake during arm cranking and combined arm plus leg exercise. *J Appl Physiol,* 1974; 36: 515-518

Suhr F, Brixius K, de Marees M, Bolck B, Kleinoder H, Achtzehn S, Bloch W, Mester J. Effects of short-term vibration and hypoxia during high-intensity cycling exercise on circulating levels of angiogenic regulators in humans. *J Appl Physiol (1985),* 2007; 103: 474-483

Thomas HJ, Scott BR, Peiffer JJ. Acute physiological responses to low-intensity blood flow restriction cycling. *J Sci Med Sport,* 2018; 21: 969-974

Van Hall G, Jensen-Urstad M, Rosdahl H, Holmberg HC, Saltin B, Calbet JA. Leg and arm lactate and substrate kinetics during exercise. *Am J Physiol Endocrinol Metab,* 2003; 284: E193-205

Wahl P, Hein M, Achtzehn S, Bloch W, Mester J. Acute metabolic, hormonal and psychological responses to cycling with superimposed electromyostimulation. *Eur J Appl Physiol,* 2014; 114: 2331-2339

Wahl P, Schaerk J, Achtzehn S, Kleinoder H, Bloch W, Mester J. Physiological responses and perceived exertion during cycling with superimposed electromyostimulation. *J Strength Cond Res,* 2012; 26: 2383-2388

Zinner C, Morales-Alamo D, Ortenblad N, Larsen FJ, Schiffer TA, Willis SJ, Gelabert-Rebato M, Perez-Valera M, Boushel R, Calbet JA, Holmberg HC. The Physiological Mechanisms of Performance Enhancement with Sprint Interval Training Differ between the Upper and Lower Extremities in Humans. *Front Physiol,* 2016; 7: 426

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