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Frequency and pattern of voluntary pedalling is influenced after one week of heavy strength training

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ABSTRACT

Changes in voluntary rhythmic leg movement characteristics of freely chosen cadence (reflecting movement frequency) and tangential pedal force profile (reflecting movement pattern) were investigated during 4 weeks of (i) heavy hip extension strength training (HET, $n = 9$), (ii) heavy hip flexion strength training (HFT, $n = 9$), and (iii) no intervention (CON, $n = 9$). Training consisted of three 5RM–10RM sets per session, with two sessions/week. Submaximal ergometer cycling was performed before the training period (pretest) and after every week of training (test A1, A2, A3, and posttest). Strength increased by on average 25% in HET and 33% in HFT. Freely chosen cadence was only changed in HET, occurring already after 1 week of training. Thus, percentage reductions of cadence in HET at test A1, A2, A3, and posttest, with respect to the pretest value, amounted for maximally on average 17%, or 14 rpm, and were larger than the corresponding changes in CON ($p = .037$). Percentage increases in minimum tangential pedal force in HET at test A1, A2, A3, and posttest, with respect to the pretest value, were larger than the corresponding changes in CON ($p = .024$). Heavy hip flexion strength training did not cause such alterations.

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1. Introduction

Walking has often been used as an exercise model for human rhythmic movement (Dietz, Colombo, & Jensen, 1994; MacLellan, Qaderdan, Koehestanie, Duysens, & McFadyen, 2012; Zehr & Haridas, 2003). Cycling is another model (Balter & Zehr, 2007; De Marchis, Schmid, Bibbo, Bernabucci, & Conforto, 2013; Sakamoto et al., 2007) that offers a more constrained movement, plus a gearing system that allows relatively low and high cadences to be applied.

It has been suggested that freely chosen cadence during submaximal cycling represents an innate voluntary rhythmic leg movement frequency, under the primary influence of spinal neural circuits referred to as central pattern generators (Hansen & Ohnstad, 2008; Hartley & Cheung, 2013). In other words, freely chosen cadence may be a good reflection of central pattern generator movement frequency output. Investigations of central pattern generator-generated voluntary rhythmic movement in healthy humans are challenged by researchers' restricted access to the spinal cord. Furthermore, it should be emphasized for completeness that existence of human central pattern generators is difficult to conclusively prove. Indirect evidence comes from spinal cord injured individuals (Calancie et al., 1994; Dimitrijevic, Gerasimenko, & Pinter, 1998) and infants (Yang, Stephens, & Vishram, 1998). Further, analysis of motor behavior can be used to increase our understanding of how the nervous system is organized and function (Goulding, 2009). Of note is that freely chosen cadence is largely individual, with a considerable range from about 50 to 100 rpm. Moreover, the freely chosen cadence is robust to acute changes such as mechanical loading and cardiopulmonary loading (Hansen & Ohnstad, 2008; Hartley & Cheung, 2013). Finally, internal (e.g., age) and external (e.g., road gradient) factors are known to change freely chosen cadence by on average up to 10 rpm. For an overview, the reader is referred to a previously published review (Hansen & Smith, 2009).

The internal organization of central pattern generators is considered to be functionally separated into two components; one responsible for rhythmic movement frequency and another responsible for rhythmic movement pattern (Dominici et al., 2011; Kriellaars, Brownstone, Noga, & Jordan, 1994; McCrea & Rybak, 2008; Perret & Cabelguen, 1980). In the present study, which addressed the voluntary rhythmic leg movement of pedalling, we considered freely chosen cycling cadence to reflect rhythmic movement frequency and tangential pedal force profile to reflect rhythmic movement pattern as it has been done recently (Hansen, Voigt, Kersting, & Madeleine, 2014). Still, it should be acknowledged that both freely chosen cycling cadence and tangential pedal force are outcomes of a complex interaction of the nervous and musculoskeletal systems that include diverse aspects as e.g., movement control and inertia.

It has previously been reported that 12 weeks of heavy leg strength training, involving a combination of hip extension and hip flexion exercise, caused recreationally active individuals to reduce their freely chosen cadence by on average 8–11 rpm during submaximal cycling (Hansen, Raastad, & Hallén, 2007; Rønnestad, Hansen, & Raastad, 2012). This constitutes a substantial alteration of human voluntary rhythmic leg movement behavior, which we would like to understand better. The reduced freely chosen cadence was observed after 4 weeks of training (Rønnestad et al., 2012). It is, however, possible that the freely chosen cadence is reduced even earlier than that. Indeed, the reduction of the freely chosen cadence could be hypothesized to occur already in the very initial phase (first couple of weeks) of the strength training period, particularly if the reduction is a result of neural adaptations. Our understanding of the rhythmic leg movement behavior could be enhanced by exploring the hypothesis that, in particular, one of the exercise types of hip extension *or* hip flexion alters the voluntary rhythmic movement behavior. As a final point, the previous studies did not investigate effects of the heavy strength training on rhythmic movement pattern. Therefore, all this lacking knowledge was investigated in the present study to enhance our understanding.

The purpose of the present study was, thus, to investigate the temporal effects of separate heavy hip extension and heavy hip flexion strength training interventions on freely chosen cadence and the tangential pedal force profile over 4 weeks.