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SPEED ADAPTATION IN CYCLE DURATION AND EMG DURING RUNNING AT DIFFERENT TERRAIN AND GROUND CONDITIONS

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Abstract

The purpose was to study how important stride parameters such as the cycle duration, electromoygraphical (EMG) burst duration and activation level change with running speed and with change in terrain and ground conditions. In total six male regional to national level elite orienteers participated in the study. Mean (range), height and weight were 25 (19-32) years, 180 (1.74-1.88)m and 71 (67-75)kg. Hip joint angular displacement was determined by means of an electrogoniometer. The electrical activity in m. vastus lateralis (VL) of the right leg was recorded with bipolar surface electrodes taped over the belly of the muscles. Electrogoniometric and EMG data were recorded by means of a portable data logger at a rate of 1000 Hz. The time between markers in test intervals was recorded by means of an ultra sound based timing system (Time-it, Eleiko AB, Sweden). The participating orienteers performed, after a warming up period, runs on four different horizontal ground surfaces; gravel road, forest terrain (low density undergrowth), timber felling and wet moss. The recordings were done during running in four different constant self determined speeds: slow, medium, fast (competition speed) and maximum speed. The cycle duration decreased in a similar manner with speed during running in all the tested terrain conditions and gravel road. The burst duration of the knee extensor m. vastus lateralis showed the same trend as the change in cycle duration with speed. The same increasing trend in mean EMG activation level with speed is seen in all terrain conditions and gravel road. However, specific differences between terrain and surface conditions in cycle duration, burst duration and EMG amplitude were present.

Key words: *speed adaptation, terrain, ground surface, orienteering.*

Introduction

Orienteering is a sport that is extremely demanding, not only with respect to work load, but also with respect to running techniques that has to be performed in different terrain and on different surfaces at different speeds. The change in surface from hard to soft and from even to extremely uneven etcetera will impose a challenge to the neuro-motor system in the execution of an optimal movement for the specific demands. From a motor control point of view it would be beneficial to use a similar basic movement pattern over the whole velocity range and on different surfaces. Very few studies have been performed in orienteering in general and biomechanical aspects in particular (Creagh & Reilly 1997). However, one exception from this is a study by Havas and Kärkkäinen (1995) that investigate the effect of running speed and surface on muscle activity during running on a path and in terrain. This study showed an increased activation of m. gastrocnemius, m. biceps femoris, m. vastus lateralis and m. rectus femoris with speed. Differences in the integrated EMG signal between running in the terrain and on a path were seen in m. gastrocnemius and m. biceps femoris but not in m. vastus lateralis and m. rectus femoris at increased relative speed. These data suggest a generic speed adaptation but specific EMG activation output related to ground surface. With reference to this the present study aimed at further investigates the cycle duration and EMG response during running in four different ground surface conditions: gravel road, forest terrain, wet moss and timber felling. Further, our aim was to investigate how a typical relevant muscle for running and cycle duration adapt to increased speed within the different terrain conditions. Thus, this investigation will add important detail information how the system solve the motor control as a response to increased speed and change in terrain and ground conditions. More specifically, the purpose was to study how important stride parameters such as the cycle duration, electromoygraphical (EMG) burst duration and activation level change with speed and with change in running terrain and ground conditions.

Material and methods

Participants. In total six male regional to national level elite orienteers participated in the study. Mean (range), height and weight were 25 (19-32) years, 180 (1.74-1.88) m and 71 (67-75) kg. The study was approved by the Regional Ethic Committee. The participants wore conventional orienteering shoes and light clothing during the tests.

Electrogoniometry. Hip joint angular displacement was determined by means of an electrogoniometer that was attached by elastic tape and straps over the hip joint (trochanter major) (Fig. 1A). Angular displacement of the hip joint of the right leg was used to determine the cycle duration (Fig. 1B). Left and right leg symmetry was assumed. Angular displacement in the sagittal plane was recorded. The electrogoniometric data was sampled at 1000 Hz. Cycle duration and stride rate was calculated from consecutive cycles of the hip angular displacement (Fig. 1B).

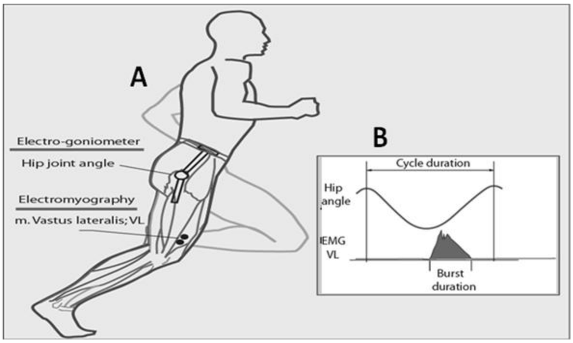

Figure 1. (A) Placement of the electrogoniometer over the hip joint and position of surface EMG electrodes over m. vastus lateralis (VL). (B) Stride cycle duration measured from onset flexion hip. The EMG burst duration of VL and area under the rectified EMG graph.

Electromyography (EMG). The electrical activity in m. vastus lateralis (VL) of the right leg was recorded with bipolar surface electrodes taped over the belly of the muscle (see Figure 1A for placement of the electrodes). The site of the electrode placement was gently shaved and cleaned with alcohol before application of the surface electrodes. The EMG data was recorded at 1000 Hz.

Data logging. Electrogoniometric and EMG data were recorded by means of a portable data logger (ME3000P, Mega Electronics, Finland).

Test settings and test speeds. The participating orienteers performed, after a warming up period, runs at four different horizontal ground surfaces; gravel road, forest terrain (low density undergrowth), timber felling and wet moss. The recordings were done during running in four different constant self determined speeds: slow, medium, fast (competition speed) and maximum speed. The test intervals were marked in the terrain settings and on a gravel road. The time between markers in the test intervals was recorded by means of a ultra sound based timing system (Time-it, Eleiko AB, Sweden). The mean velocity was calculated by dividing the length between time markers by the time spent between the markers. The participants were allowed repeated runs (shorter than 15s) in the test intervals if the preferred speed was not reached and rest periods (about 90s) were allowed between runs to avoid that fatigue affected the performance by the participants.

Analysis. The stored data was analyzed by means of a custom made program script in the Matlab® software (Matlab Inc. USA). The hip angular displacement (onset flexion in one cycle to onset flexion in the following cycle) was used to determine the stride cycle duration in repeated cycles (see Figure 1 B). Each EMG burst was rectified and filtered and the mean EMG amplitude was calculated by dividing the area under the EMG curve by time.

Statistics. Standard descriptive statistics including means, standard deviations (sd) and ranges were employed in the data analysis. Differences between mean data were tested using repeated measures ANOVA and the alpha level was set to 0.05 to assume statistical significance. Post hoc comparisons were made using the Tukey procedure.

Results

The cycle duration decreased in a similar manner with speed during running in all the tested terrain conditions and gravel road (Fig. 2A). The burst duration of the knee extensor m. vastus lateralis showed the same trend as the change in cycle duration with speed (Fig. 2B). The same increasing trend in mean EMG activation level with speed was seen in all terrain conditions and gravel road (Fig. 2B-C). Specific differences in cycle duration, burst duration and EMG amplitude are present in Figure 2.

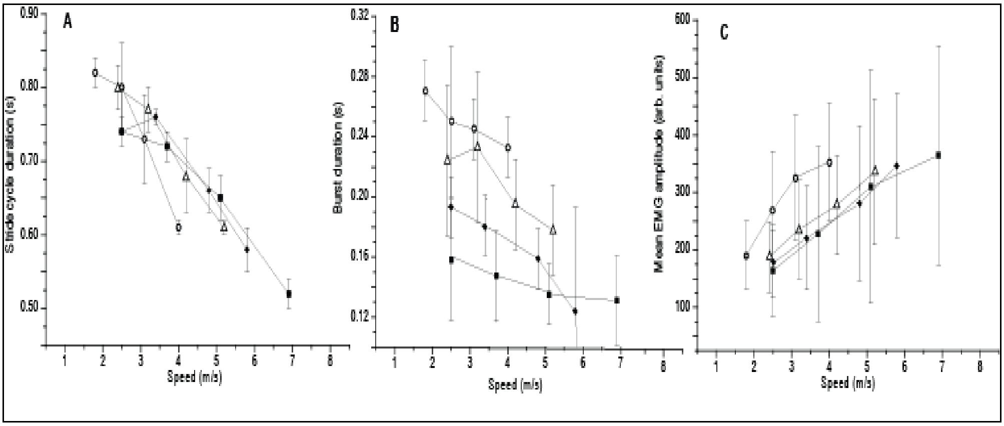

Figure 2. Changes in mean (± sd) stride cycle duration (A), VL burst duration (B) and EMG amplitude (C)versus speed during running on a gravel road (filled squares), forest terrain (filled circles), timber felling (open triangles) and wet moss (open circles).

Discussion

The clear trends in stride cycle duration and EMG during running in different terrain and on different surfaces with speed indicate that the neuro-motor system tends to adapt the control of locomotion with a similar basic pattern in the studied parameters (cf. Nilsson et al. 1985, Nilsson & Thorstensson 1987). Despite the similar generic trends in stride cycle duration and EMG in different terrain settings and on gravel road as well as different speeds there are specific differences that will be discussed in the following section.

The speed range from perceived slow to maximum (i.e. peak speed) for this group of male elite orienteers was about 5 m•s^{-1} (approximately 2-7 m•s^{-1}) (Fig. 2A-C). It is obvious that terrain setting and surface conditions influenced the speed range in the order; wet moss, timber felling, forest and gravel road. The maximum average speed running in the wet moss was almost 4 m•s^{-1} but the maximum speed was much higher, approximately 7 m•s^{-1} when the elite orienteers ran on a gravel road. Therefore, surface conditions such as undergrowth, type of surface (such as wet moss and gravel road) and the impact response i.e. stiffness of running surface seem to have clear effect on the speed. Running on the extremely compliant surface wet moss only allowed a maximum speed of about 60 percents of the speed obtained on a gravel road.

The average stride cycle duration ranged from about 0.8s to about 0.5s from slow to maximum speed. This corresponds to about 1.2Hz at slow speeds to about 1.5-2.0Hz at maximum speed. The shortest stride cycle duration i.e. the highest stride frequency at maximum speed was in the order; running on gravel road, forest terrain, timber felling and wet moss, respectively. The differences in stride cycle duration and stride frequency between the different terrain settings were significant at maximum speed. It is worth noting that the stride cycle duration during wet moss running at maximum speed is significantly shorter than other terrain settings tested at compatible speeds. It is assumed that the compliant base of support of the wet moss does not allow a leg thrust that cause a long flight phase, which reduces the stride cycle duration. The burst duration of m. vastus lateralis follows the order; wet moss, timber felling, forest terrain and gravel road at almost all speed levels from low to maximum (Fig. 2B). It is obvious from Figure 2B that the burst duration is longer in wet moss running at all speeds compared to all other test settings. This is also seen in the relative support phase duration (represented by the knee angular displacement) in wet moss running at competition speed, which is longer than in other terrain conditions (Nilsson et al. 2013a). Also the burst duration during running in timber felling is longer than running in forest terrain and on a gravel road. It is assumed that the elongation of burst duration may be caused by the compliance as well as density and complexity running in wet moss and timber felling, respectively. The elongation of the burst duration i.e. a longer activation of the muscle is one prerequisite for longer contraction and thereby a larger metabolism at given speeds and muscle activation levels. The mean EMG level during wet moss running showed larger values than in the other tested terrain settings and gravel road running at comparable speeds. This indicates that the orienteer has to activate m. vastus lateralis to a larger extent at comparable speeds. The larger muscle metabolism related to the higher mean activation level causes larger energy consumption for a given speed. In addition, the longer burst duration may occlude the blood flow to a larger extent restricting the oxygen to reach the musculature which in turn may cause a larger local anaerobic metabolism in vastus lateralis with an increased risk of local fatigue.

The specific differences between the various terrain test settings calls for a more specific view on training. The results in this study point at the importance of specific adaptation to speed and terrain condition. This is important information in endurance and strength training design and for the acute route choices in an orienteering race.

Conclusions

The cycle duration and burst duration of the knee extensor m. vastus lateralis decreased in a similar manner with speed during running in all the tested terrain conditions. The same increasing trend in mean EMG activation level with speed is seen in all terrain conditions and gravel road. However, specific differences in cycle duration, burst duration and EMG amplitude were present.

References

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