ORIGINAL RESEARCH PAPER

MUSCLE ACTIVATION LEVEL IN GENERIC AND SPECIFIC STRENGTH TRAINING EXERCISES FOR ORIENTEERS

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Abstract

The purpose was to compare the EMG activation level in specific strength training exercises used by orienteers with the activation level in generic strength exercises and MVDA (maximum voluntary dynamic action) in order to evaluate possible strength training potential in the specific exercises. 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 electrical activity in m. gluteus maximus (GM), m. rectus femoris (RF), m. vastus lateralis (VL) and m. soleus (SOL) of the right leg was recorded with bipolar surface electrodes. The EMG data was recorded at 1000 Hz with a portable data logger. The participants performed the following generic strength exercises: 5RM (repetition maximum) squats and 5RM ankle extensions on the right leg. In addition MVDA in form of 5 consecutive maximal vertical jumps were performed on the right leg and with both legs. The participants performed the following specific exercises: leaping i.e. running with very long strides and maximal effort on a horizontal gravel stone road and uphill in forest terrain. Both generic (squats and ankle extensions) and specific strength training exercises (leaping on the horizontal and uphill) reached sufficiently high relative EMG levels. The results also show that the activation levels during the specific strength exercises are compatible with the 5RM generic exercises commonly used to increase muscle strength.

Key words: *Specific strength training, activation level, leaping.*

Introduction

Orienteering is a typical aerobic sport i.e. the time when the orienteer utilize a large part of their aerobic power is so long that in sprint orienteering distances and longer the major energy contribution will come from aerobic energy processes (Åstrand & Rodahl 1986, Bird et al. 1993, Jensen et al. 1994). However, there are situations in an orienteering course such as steep inclines and rough terrain when muscle action may need to be much larger than the average muscle action used in the course. This emphasize the need for strength training among orienteers.

Although the strength training is a relatively small part of the total training volume among orienteers it may still be important for the performance in orienteering. Previous studies have shown that the increased strength may contribute to improvement in running economy as reviewed by Saunders and co-workers (2004). However, to our knowledge it is still not shown if the results obtained in studies on strength training with weights and running economy on the flat also comprise improved running economy in the terrain. According to Sale and MacDougall (1981) training is specific with respect to muscle action type, speed of contraction and muscle length/joint angle. This leads the question towards specific strength training. It would be safer concerning specificity in speed, angular displacement and muscle action type if the strength training could be performed in a running like action. This form of strength training is sometimes performed with leaping, which is running with a powerful and overemphasized running movement amplitude and stride length on level ground and uphill (see Figure 2). Each running cycle is performed with maximal effort and the running sequences are seldom longer than 10 to 20 seconds. The rest periods between runs are long enough to recharge phosphate depots. The typical running-like movement pattern is indicative for a larger degree of specificity compared to generic strength training exercises. However, the question arises if the relative muscle tension is large enough to stimulate improvement in strength.

To improve muscular strength a relative tension in the musculature of approximately 60 - 70 percent of one repetition maximum (1RM) is needed (McDonagh & Davies 1984). By means of electromyography (EMG) it is possible to determine the EMG activation level at different levels of 1RM in generic exercises such as squats and ankle extensions. It is also possible to determine the highest EMG activation level in different maximal voluntary dynamic actions (MVDA) such as in vertical jump, squat and ankle extension. The relationship between activation level and relative muscle tension (% 1RM) allow specific strength training exercises among orienteers to be evaluated. The purpose of the present study was to compare the EMG activation level in specific strength training exercises used by orienteers with the activation level in generic strength exercises and MVDA in order to evaluate possible strength training potential in the specific exercises.

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 clothes during the tests.

Electromyography (EMG). The electrical activity in m. gluteus maximus (GM), m. rectus femoris (RF), m. vastus lateralis (VL) and m. soleus (SOL) of the right leg was recorded with bipolar surface electrodes taped over the belly of the muscles (see Figure 1 for placements of the electrodes). The site of the electrode placement was gently shaved and cleaned with alcohol before application of the surface electrodes.

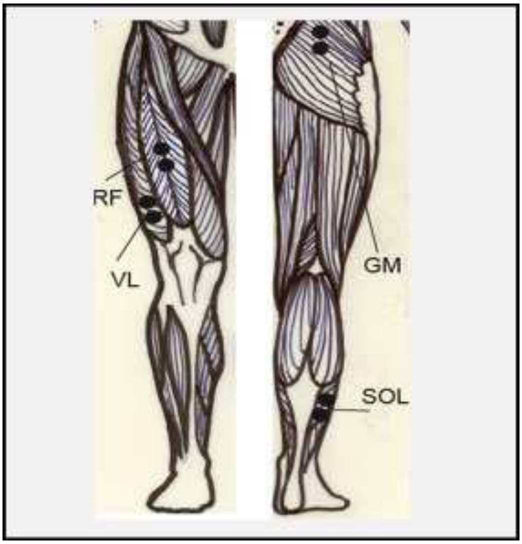

Figure 1. Placement of the surface electrodes on *m. gluteus maximus* (GM), *m. rectus femoris* (RF), *m. vastus lateralis* (VL) and *m. soleus* (SOL) of the right leg.

Data logging. EMG data were recorded by means of a portable data logger (ME3000P, Mega Electronics, Finland) and sampled at 1000Hz.

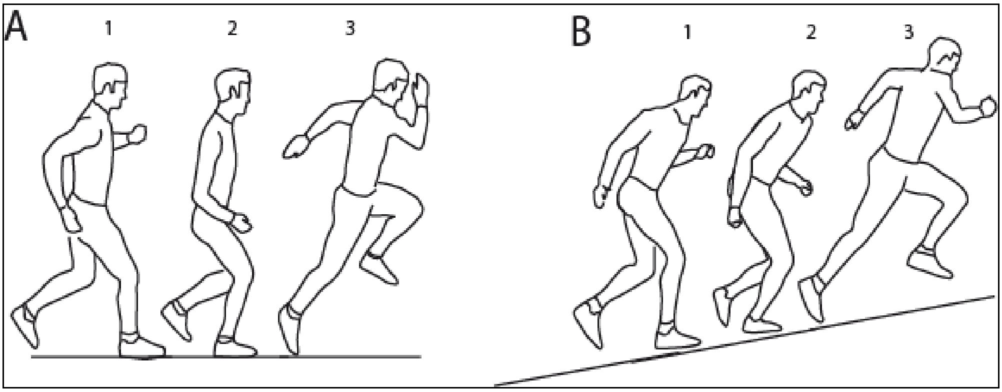

Figure 2. The support phase of the right leg during leaping on a level gravel road (A) and uphill in the forest (B)

Procedures. The participants performed the following generic strength exercises: 5RM squats and 5RM ankle extensions on the right leg. In addition MVDA in form of 5 maximal vertical jumps were performed on the right leg and with both legs. The participants performed the following specific exercises: leaping i.e. running with very long strides and maximal effort on a horizontal gravel road and uphill (7 degrees slope) in forest terrain with light undergrowth (Figure 2). All exercises were recorded. The maximal average level of EMG activity during the generic exercises and MVDA was set to 100%.

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

Figure 3 shows that both generic (squats and ankle extensions) and specific strength training exercises (leaping on the horizontal level and uphill) reach higher mean levels of EMG activation than was suggested by McDonagh & Davies (1984) for adaptive responses in mammalian skeletal muscles to exercise. The results also show that the activation levels during the specific strength exercises are compatible with the 5RM generic exercises commonly used to increase muscle strength.

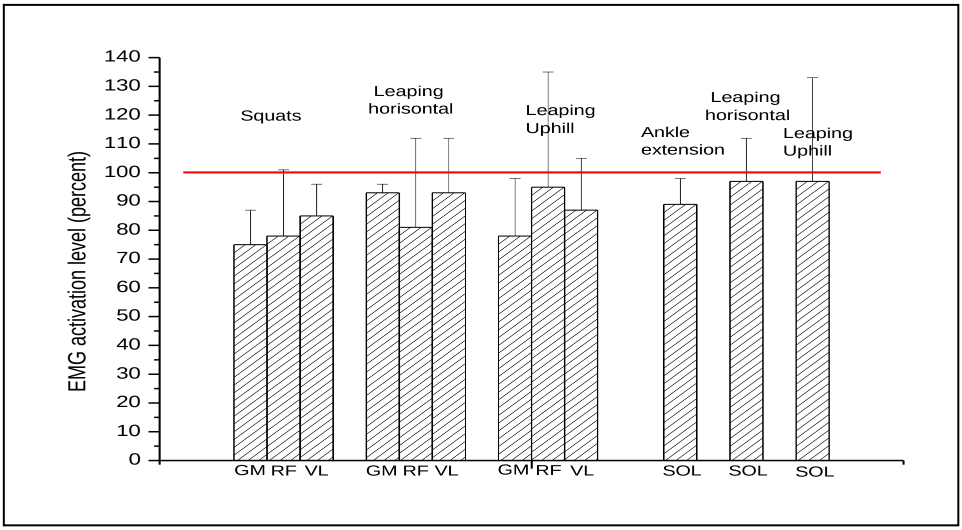

Figure 3. Mean (+sd) EMG activation level in generic strength exercises (squats and ankle extensions) and specific strength training exercises (leaping on the horizontal and uphill). Recorded muscles: *m. gluteus maximus* (GM), *m. rectus femoris* (RF), *m. vastus lateralis* (VL) and *m. soleus* (SOL). The reference muscle activation level representing 5 RM squats and vertical jumps is set to 100 percent.

Discussion

From the results in the present investigation it can be concluded that the EMG activation level in specific strength exercises such as leaping on level ground and uphill are compatible with mean EMG activation level in generic strength exercises and with respect to maximal EMG activation levels, which indicate a possible strength training potential. The high activation levels obtained in leaping compared to generic strength training methods indicate that the training form can compete with generic training forms concerning muscle activation.

In the studies performed on strength training and running economy it is shown that increased muscle strength is associated with a better running economy (for references see Saunders et al. 2004). Today, we do not know if increased muscle strength also improve running economy in orienteering terrain. However, the implementation of leaping, which is an exaggerated form of running, the prerequisite for specificity is fulfilled. It is reasonable to suggest that the range of motion of the hip, knee and ankle joints in the support phase (which is assumed the most relevant phase with respect to specificity) during leaping (cf. Figure 2) are larger than normal running at different speeds. This means that all smaller angles i.e. muscle lengths are comprised in leaping. The muscle length in leaping is probably on the extreme side of what can be expected when running in the terrain. The duration of the support phase is somewhat longer in leaping compared to e.g. running at competition speed (approximately 0.20 and 0.25 s, respectively) but only on one extreme side of the range in normal running (Nilsson and Thorstensson 1987). Looking at the flexion – extension angular displacement during the support phase in the hip, knee and ankle joint during leaping (Figure 2) it is reasonable to conclude that the type of muscle action for GM, VL and SOL must be similar to normal running.

With the above presented data it is reasonable to assume that leaping show specificity with respect to normal running but still with a high degree of muscle activation. This may have impact on the running economy on a gravel road but also in terrain. Future studies should emphasize the analysis of running economy in terrain after intervention periods of generic and/or specific (for example leaping) strength training. Information obtained in this study can be used to enable a development of specificity in strength training and also a larger degree of integration between trained capacities among orienteers.

Conclusions

The EMG activation in the specific strength exercise leaping on horizontal level and uphill are compatible with mean EMG activation levels in generic strength exercises and with respect to maximal EMG activation levels i.e. indicating a possible strength training potential.

References

1. McDonagh, M.J.N., & Davies, C. T.M. (1984) Adaptive Responses of Mammalian Skeletal Muscle to Exercise with High Loads. *Eur J A ppl Physiol*, 52, 139-155.
2. Jensen K, Franch J, Kärkkäinen O., et al. (1994) Field Measuerements of Oxygen Uptake in Elite Orienteers During Cross-country Running Using Telemetry. *Scand J Med Sci Sports*, 4: 234-238.
3. Bird SR, Bailey R, Lewis J. (1993) Heart Rates During Competitive Orienteering. *Br J Sports Med*, 27: 53-57.
4. Åstrand PO, Rodahl K. (1986) Textbook of Work Physiology: Physiological Bases of Exercise, 3rd ed. London: McGraw-Hill Book Company.
5. Sale, D.G. & MacDougall, D. (1981) Specificity in Strength Training: A review for the Coach and Athlete. *Can J Appl Sport Sci*, 6(2): 87-92.

6. Nilsson, J. & Thorstensson, A. (1987) Adaptability in Frequency and Amplitude of Leg Movements During Human Locomotion at Different Speeds. *Acta Physio Scand*, 129: 107-114.
7. Saunders, P.U., Pyne, D.B., Telford, R.D. and Hawley, J.A. (2004) Factors Affecting Running Economy in Trained Distance Runners. *Sports Med*, 34(7): 465-485.

Submitted: October 23, 2013
Accepted: November 27, 2013