

CHANGE IN TRUNK MUSCLE ACTIVITY DURING INCLINE TREADMILL RUNNING

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This study examined the effect that increasing incline has on the muscle activity of three different muscles of the trunk during treadmill running. Eight female subjects participated in 3 consecutive 30 second trials, running at a pace equal to their personal best for a cross country race. The three trials were completed at inclines of 0, 2 and 4 percent. Surface electromyography data was recorded on the rectus abdominis, external oblique and multifidus. All muscle activity was recorded on the left side of the subjects. Results showed that there is no significant interaction between muscle activity and change in incline. The results did show that there is a significant difference in muscle activity between the different muscles during all four phases of the running stride.

KEYWORDS: electromyography, core muscles

INTRODUCTION: The importance of having strong musculature through the trunk and its relation to sport performance has been well documented. The muscles of the trunk are vital in helping to stabilize the spine during movement as well as in the transfer of energy from large muscle groups to small muscle groups in many sporting activities (Kibler et. al, 2006). The musculature of the hip, pelvis and spine all contribute to stabilizing the body while distal segments perform their function (Kibler et. al, 2006). Nearly all activities of the extremities involve the muscles of the core (Kibler et. al, 2006).

Running is a sport in which there is considerable movement of both upper body and lower body extremities. The unilateral hip flexion and extension movements that occur during running have the potential to place substantial destabilizing torques on the trunk (Schache, 1999). Dintman and Ward (2003) state that in order to run economically, the upper body movements and reaction forces of the lower limbs must be stabilized by the muscles of the trunk. Because of the forces the extremities place on the trunk while running, the musculature of the trunk plays an important role in running performance. Sato and Mokha (2009) found that following a 6 week core strength training program the subjects following a core strength program were able to reduce their 5,000 meter times by a mean of 47 seconds as compared to a reduction of 17 seconds for the control group. A typical women's collegiate cross country running race is run over a 6 kilometer course with many variances in terrain and elevation. A successful and economical runner must be able to stabilize the reaction forces of the lower limbs through use of the trunk muscles. The purpose of the current study is to investigate the changes in muscle activity that occur when a runner is subject to varying incline levels.

METHODS: Eight female Division II cross-country runners participated in this study. The mean age ± SD was 19.0 ± 0.76 y, height was 160.9 ± 6.8 cm and mass was 54.1 ± 3.6 kg. All participating subjects were in the final month of the cross country competition season. The current study was approved by the Institutional Review Board at Northern Michigan University. Prior to participation the subjects signed an informed consent and completed a PAR-Q form (Physical Activity Readiness Questionnaire, Canadian Society for Exercise Physiology, 2002).

Three muscles were examined using surface electromyography. The rectus abdominis (RA), external oblique (EO) and multifidus (M) were all fitted with surface electrodes on the left side of the subject. Prior to electrode placement a rough abrasion pad was rubbed over all the sites of placement to remove dead skin and lessen impedance. Rubbing alcohol was then applied to a gauze pad and rubbed over the abrasion sites to remove any skin oils. The subject was then fitted with a Noraxon Dual Electrode (Product #272 Noraxon USA;

Scottsdale, AZ). One drop of Signa Electrode Gel (Parker Laboratories, Inc.; Fairfield, NJ) was placed on each electrode prior to placement. The electrode placed on the RA was placed 2 cm to the right of the navel. One electrode was placed on the M, 3 cm from the spinal cord. The final electrode was placed on the EO midway between the 12^{th} rib and the iliac crest. Three ground electrodes were placed on the iliac crest. Impedance between electrodes was tested and verified at below 5000Ω. Following electrode placement the subject was allowed to warm-up on the treadmill at a self selected pace for a self selected amount of time. The electrodes were then attached to the Biopac Systems, Inc. MP150 (Goleta, CA). A Biopac UIM 100A EMG Amplifier (Biopac Systems, Inc. Goleta, CA) was used with a gain of 1000, and a band pass filter of 10 to 500 Hz. All EMG data were analyzed using AcqKnowledge 3.9.1 software (Biopac Systems Inc., Goleta, CA). Data were collected at a sampling rate of 1000 and was rectified using root mean square and averaged over 100 ms. A light was attached to the amplifier to act as a signal to synchronize the video and the EMG data. Each trial was recorded at 60 Hz with a shutter speed of 500 using a Panasonic Digital Video Camera (Model No. PV-G535, Panasonic, Secaucus, NJ). The video was then analyzed using PeakMotus 8.5 Software (Peak Performance Technologies Inc., Englewood, Colorado) to determine foot and ground contact time and the corresponding muscle activity.
Prior to the trial a maximal voluntary isometric contraction (MVIC) was performed on each of the three muscles. The subject performed one trial each of trunk flexion, trunk extension and lateral trunk flexion. The subject performed each movement while standing against a handrail of the treadmill and pushing against the resistance of an assistant.
Following the warm-up period the subject began to run on the treadmill at a pace equivalent to her personal best for a collegiate cross country race. Mean velocity was 4.08 ± 0.18 m·s^{-1} for the eight subjects. Each subject ran at her pace for three different inclines. The subject began at a 0 percent incline, followed by a 2 percent incline which was followed by a 4 percent incline. Each subject ran for 30 seconds at each incline level. Once electromyographical data was collected, the incline was increased.
One complete stride was analyzed for each of the three incline levels. One stride was characterized by two ground contact times and two flight times. The first ground contact phase was defined from the time the left foot first made contact with the ground until the left foot lost contact with the ground (Left Contact). The first flight phase was defined as the time in between the left foot losing contact with the ground and the right foot making contact with the ground (Left Air). The second ground phase was defined as the time from initial right foot contact through the loss of contact with the ground of the right foot (Right Contact). The second flight phase was defined as the time from the right foot losing contact with the ground until the left foot made contact with the ground again (Right Air).
Statistical comparisons were made using SPSS (v.18, Chicago, Illinois, USA) via Two-Way Repeated Measures ANOVA (muscle X stage) the muscle activity relative to MVIC. Significance was set at $\alpha = 0.05$ and follow-up pair-wise comparisons were performed with Bonferroni's test.

RESULTS: Results of the ANOVA revealed no significant interaction between muscle and incline ($p < 0.05$). The results also displayed no significant interaction between incline and phase of the running stride ($p > 0.05$). When the activity of each muscle was compared to the other muscles, M displayed a significant difference ($p < 0.05$) in activity to RA. This occurred across all four phases of the running stride. In addition, M displayed significant difference ($p < 0.05$) in activity from EO in the Left Air, Right Contact and Right Air phases. Table 1 below displays the results.

DISCUSSION: The purpose of this study was to determine if an increase in incline had an effect on trunk muscle activity. While there was no significant interaction between muscle and incline, the results of this study indicate that the M is active at a greater percentage of its MVIC over the course of the whole running stride than the RA and EO. The percentage of MVIC results are similar to the ones by Saunders et al. (2005) who stated that during fast running bursts of trunk muscle activity can range anywhere from 10-100 percent of MVIC.

Saunders et al. (2005) also stated that increased EMG amplitude was associated with increased lumbo-pelvic motion. Saunders et al. (2005) found that EMG activity was greater during locomotion at higher velocities as compared to lower velocities. Because the subjects in the current study were running at a high velocity, it is expected that the EMG activity would be high.

Table 1
Values are mean MVIC values ± SD expressed as a percentage for each phase of the stride, incline and muscle (n = 8)

		0%	2%	4%
Left Contact				
	RA	34.4 ± 30.7	31.3 ± 26.3	37.9 ± 31.7
	EO	63.2 ± 51.1	63.6 ± 36.7	64.1 ± 48.8
	M_a	91.7 ± 23.4	92.3 ± 23.5	88.9 ± 30.4
Left Air				
	RA	31.3 ± 25.4	31.4 ± 20.3	32.0 ± 23.5
	EO	72.7 ± 77.1	38.2 ± 21.8	39.1 ± 25.3
	M_{ab}	91.4 ± 23.5	89.0 ± 16.3	86.2 ± 24.6
Right Contact				
	RA	33.2 ± 22.9	26.2 ± 19.6	30.3 ± 25.1
	EO	54.6 ± 47.3	44.6 ± 36.8	41.9 ± 28.5
	M_{ab}	88.2 ± 22.5	89.3 ± 22.1	84.0 ± 28.7
Right Air				
	RA	24.8 ± 16.4	27.3 ± 24.9	32.3 ± 30.4
	EO	43.6 ± 33.8	55.5 ± 44.8	48.0 ± 35.9
	M_{ab}	88.3 ± 14.6	84.5 ± 23.4	82.3 ± 26.7

[a] M varied significantly from RA where $\alpha < .05$
[b] M varied significantly from EO where $\alpha < .05$

The high percentage of MVIC that is apparent in the M suggests that it plays an important role while running and indicates the importance in developing the posterior muscles of the trunk as well as the anterior muscles. This is in agreement with Sato and Mokha (2009) who found that a core strength training program can improve 5000 meter running times. While the study by Sato and Mokha (2009) tested subjects running on outdoor tracks, cross country races are run over similar distances at a similar pace. The fact that a core strength training program can help improve performance in distance runners suggests the importance of the trunk muscles in running performance.
The current study only examined the change in muscle activity during increasing incline. During a cross country race the terrain can vary greatly. This can include uphill, downhill and side-hill running. More research should be done to investigate the change in muscle activity during the change in terrain over the course of a cross country race. Further research can also investigate the effect greater inclines have on changes in muscle activity.

CONCLUSION: For the incline level test the trunk muscle activity does not change with increasing incline while running on a treadmill. The muscle activity of the M during treadmill running is a high percentage of its MVIC. This indicates that the multifidus plays an important role while running and suggests the importance of developing the posterior muscles of the trunk as well as the anterior muscles.

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