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From: Janet S. Dufek, Ph.D.

Subject: Exercise Equipment Evaluation Report: Skorcher

Overview

A project was undertaken to evaluate adductor longus (ADL), biceps femoris (BF), gluteus maximus (GM), and rectus femoris (RF) muscle activity during performance of five strength training exercises. The exercises evaluated included the squat, deadlift, lunge, single leg hip thrust and double leg hip thrust. The latter two exercises were performed using a "Skorcher" exercise machine and will subsequently be referred to as SL Skor and DL Skor, respectively. Ten healthy, untrained male and female volunteers performed each of the exercises following a specific protocol (see Appendix A for participant characteristics and protocol description).

Three specific analysis questions were posed. These questions were:

1) What are the effects of the squat, deadlift, lunge, SL Skor and DL Skor on activation of ADL, BF, GM and RF muscles?

2) Is there a difference between the magnitude of GM muscle activation between a voluntary maximum contraction of the gluteal muscles and SL Skor or DL Skor exercise?

3) Is there a relationship in the recruitment patterning of ADL, BF, GM and RF muscles between sprinting and performance of SL Skor exercise?

Results

Analysis Question 1

Results of the analysis identified significantly greater ($p < 0.002$) BF, GM, and RF activity when comparing DL Skor to the deadlift and squat exercises. ADL activity was significantly greater for DL Skor versus the deadlift.

When normalizing all exercises to lunge with no load (lunge0) and evaluating across all muscles, SL Skor ranked first, that is, the greatest percent muscle activation across all four muscles was demonstrated for this exercise. This result suggests that SL Skor provided the greatest overall muscle activation level when referenced to a lunge with no load in comparison to all other exercises performed. Figure 1a illustrates not only the overall effect of SL Skor on increased muscle activation (with the exception of RF), but also illustrates the differential effects per muscle group by exercise. Figure 1a also illustrates the increased activation of DL Skor for ADL, BF, and GM muscle activity, relative to a baseline exercise of lunge0.

Of practical interest was the comparative involvement of hip adductor muscles across exercises. Due to surface EMG limitations, the ADL was the only hip adductor muscle that could be accurately monitored. A graphical summary of this assessment, across all exercises, is given in Figure 1b. This figure clearly illustrates the dominance of SL Skor for maximal EMG activation relative to the other exercises. It should be noted also that DL Skor produced greater hip adductor activity versus either the deadlift or squat at comparable resistance levels.

Exercises performed were either single limb actions (lunge0, SL Skor) or dual-limb actions with a 45 lb load (deadlift45, DL Skor45, squat45). The rank order relative to greatest EMG activity across all muscles for single limb activities was SL Skor followed by lunge0. For bilateral activities, the ordering was DL Skor45, followed by deadlift45 and squat45 equally. This result (shown graphically in Figure 1c) suggests that the Skorcher augmented overall EMG activity across three of the four muscles evaluated (hip adductor and extensors) in comparison to the three traditional strength training exercises that were evaluated (lunge, deadlift, squat) for both single and dual leg exercises.

Figure 1a. Percent Muscle Activation Relative to Lunge (no load)

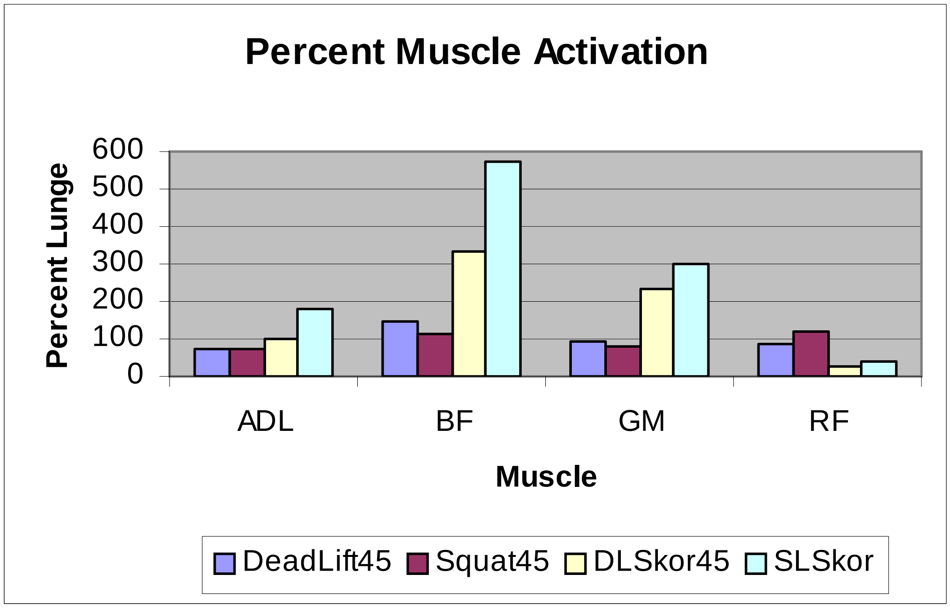


Figure 1b. Percent Hip Adductor Activation Relative to Lunge (no load)

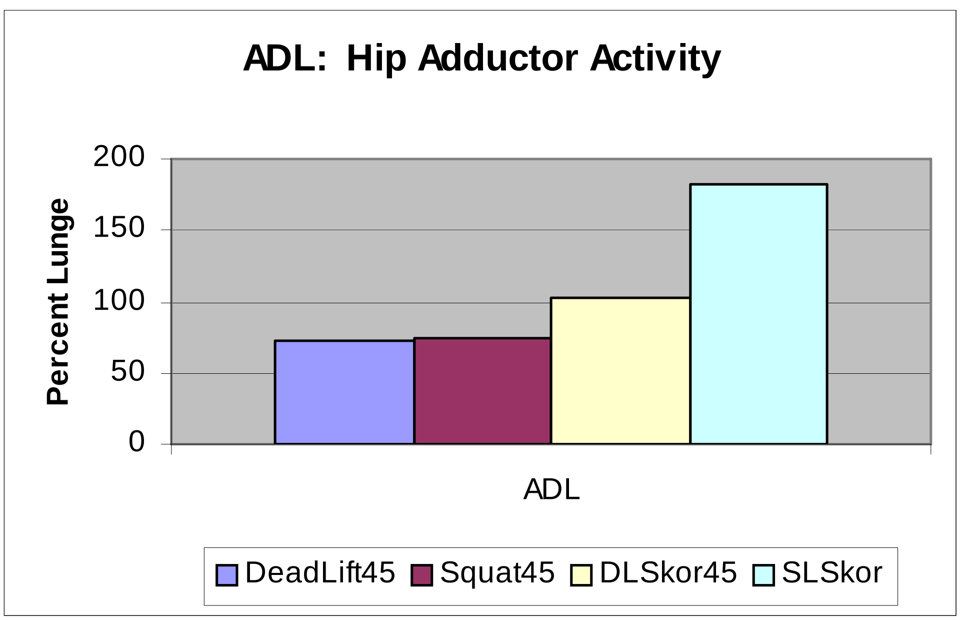
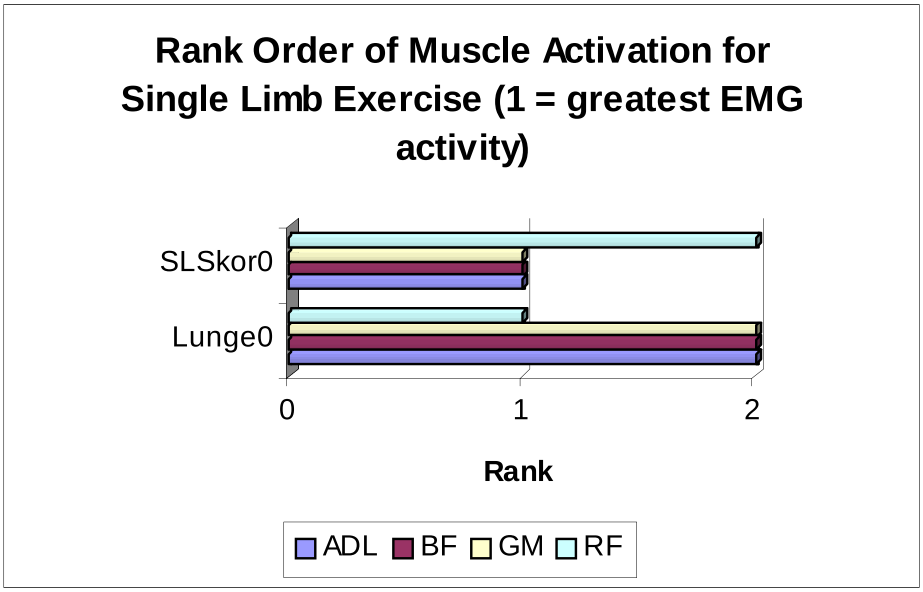
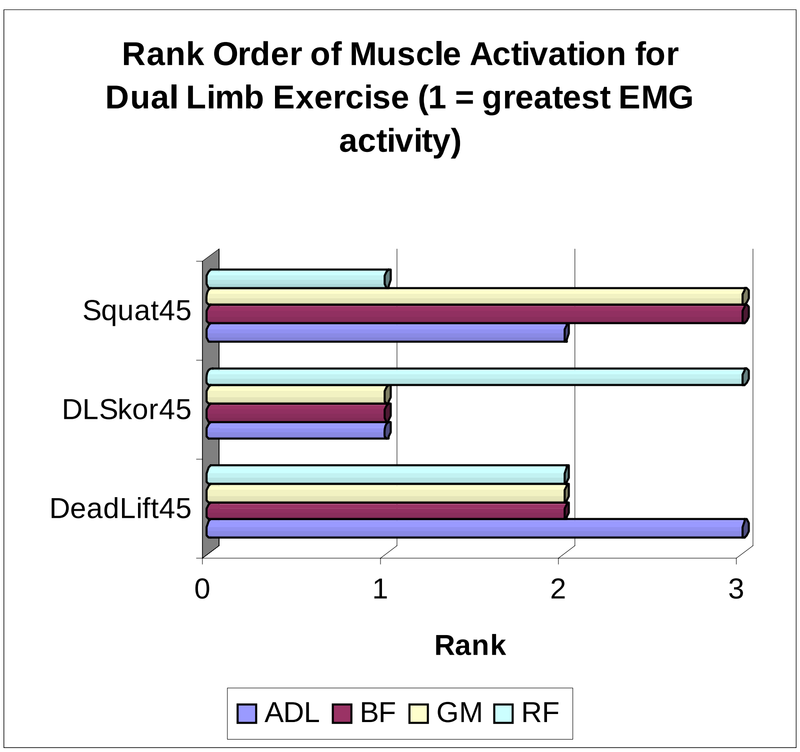


Figure 1c. Relationship of Muscle Activation Level to Exercise

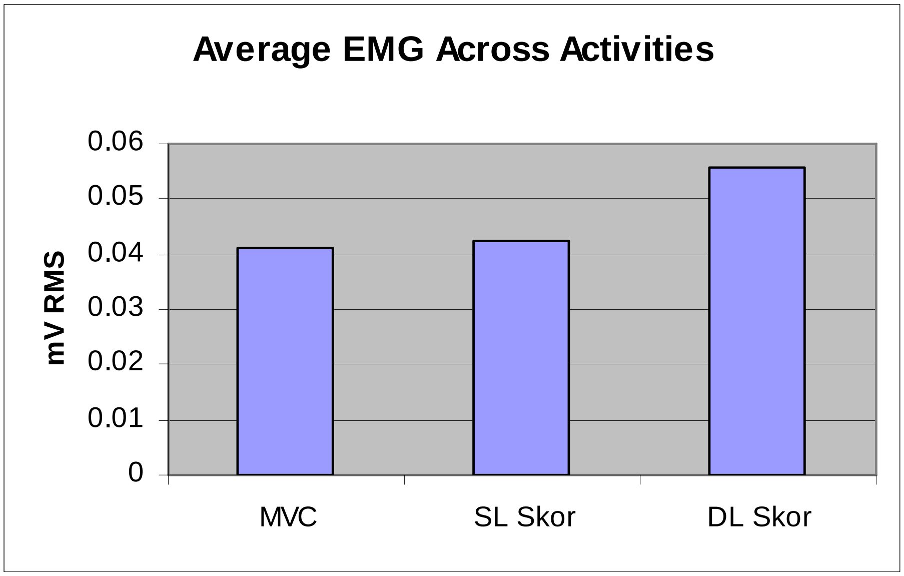




Analysis Question 2

Muscle activation of the GM during maximum voluntary contraction (MVC) of the gluteal muscles was compared to GM activity during performance of SL Skor and DL Skor. Results of this analysis identified a significant difference ($p < 0.0013$) between MVC and SL Skor. Across all participants, the average GM muscle activation was least for MVC. These results are illustrated in Figure 2.

Figure 2. Average GM Activation Among MVC, SL Skor and DL Skor

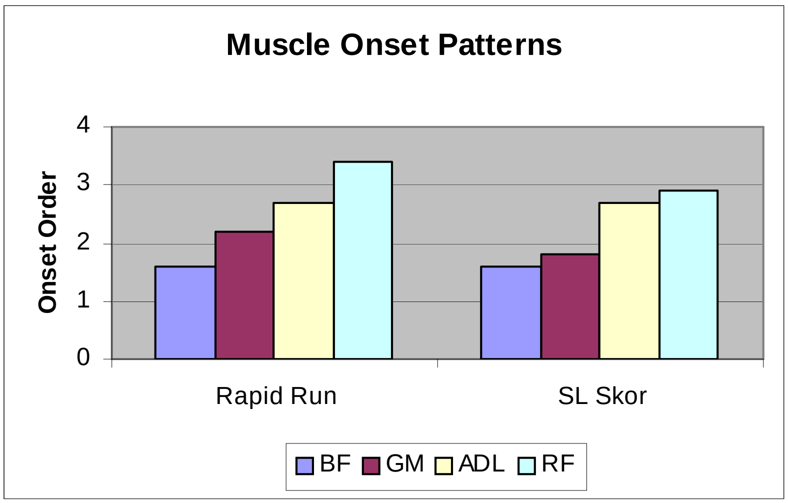


Note: mV RMS = millivolts root mean square
(higher value represents greater muscle activation)

Analysis Question 3

Pattern of onset of ADL, BF, GM and RF during rapid treadmill running (sprinting) was compared to SL Skor. No statistically significant relationships were identified between exercises across muscles, however, across all subjects, the average pattern of muscle onset was similar between conditions (Figure 3).

Figure 3. Comparison of Average Muscle Temporal Onset Between SL Skor and Rapid Treadmill Running



Summary

Results of this evaluation indicated that:

- SL Skor and DL Skor elicited greater ADL, BF and GM activity than squat45 and deadlift45;
- Overall average GM activity was greater for SL Skor and DL Skor versus a maximum voluntary contraction of the gluteal muscles;
- Onset (patterning) of ADL, BF, GM and RF was similar for SL Skor and a rapid run performed on a treadmill.

Appendix A

Methods

Participants

Ten participants (8 male, 2 female; M ± SD age: 36 ± 5.0 yr; height: 1.76 ± 0.10 m; mass: 83.8 ± 22.3 kg; Table 1) volunteered to take part in an exercise evaluation. Participants self-reported a physical activity level ranging between zero and eight (M ± SD: 3.0 ± 2.7) on the Wojtys et al (1996) physical activity level scale. On this scale, a score of zero indicates sedentary / inactive, while a score of eight indicates regular recreational jumping, turning, and twisting sports. No participants were actively involved in a regular weight training program at the time of this evaluation.

Instruments

Each participant was instrumented with bipolar surface electromyographic (EMG) electrodes (Noraxon Single Electrodes, 2.5 cm center-to-center distance) positioned to record activity of the adductor longus (ADL), biceps femoris (BF), gluteus maximus (GM), and rectus femoris (RF) of the dominant lower extremity. Standard EMG skin preparation methods were used including shaving, cleansing with alcohol and lightly abrading the skin with abrasive gel in order to reduce impedance. The electrode pairs were aligned parallel to the fibers and positioned over the belly of each muscle. Proper placement was determined by palpation (Hoppenfeld, 1976) and in accordance with a standard anatomical chart for electrode placement (Konrad, 2005). A 4-channel EMG system (Noraxon Myosystem 2000) was used to sample raw EMG signals via a data acquisition system (National Instruments DAQ Pad 6020E; 1000 Hz) using a laptop computer and a custom data acquisition program (Matlab R2006b; The MathWorks, Inc.). An electronic goniometer (Biometrics, Ltd; DLK 800 and Q150) was positioned on the lateral aspect of the knee and affixed to the skin in order to obtain cycle (repetition) information during the exercises.

Protocol

Participants arrived at the laboratory and were introduced to the protocol, including a brief description of the exercises. Each participant was permitted to practice the exercises and warm-up as needed. Participants were instrumented with the EMG electrodes and the electronic goniometer as described previously. Proper placement of each EMG electrode was verified by sampling data from each muscle during isolated contractions. Each participant then performed the following exercises targeted toward the dominant (instrumented) lower limb: (1) lunge (dominant limb forward) with no external load, (2) maximum isometric gluteus maximus contraction, (3) squat with 45 lb external load, (4) deadlift with 45 lb external load, (5) lunge with 45 lb external load, (6) double limb Skorcher hip thrust with 45 lb external load, (7) single limb Skorcher hip thrust with no external load, and (8) rapid run on a treadmill. Exercises three through seven were performed by participants in a random order. Participants performed five repetitions of each resistance exercise. Approximately 8-10 seconds of data were obtained during the rapid treadmill run in order to capture a minimum of five usable strides. A one minute rest period (minimum) was provided between each exercise.

Data Reduction

Five repetitions (as defined by the goniometer data) were analyzed for each participant during each resistance exercise. For analysis purposes, a repetition was defined to occur from maximum knee flexion during an exercise to the next subsequent maximum knee flexion during the same exercise. Maximum knee flexion was chosen to represent the beginning and end of a repetition because this event was common to all exercises and was easily identifiable using the goniometer data. EMG data during the five repetition period (including contraction and relaxation phases) were digitally filtered (high and low pass cut off frequencies of 20 and 400 Hz, respectively) and the root mean square (RMS) averages were calculated using a custom analysis program in Matlab. Both raw (mV) and normalized (%) EMG RMS values were used in the subsequent analysis. The normalized data for the five muscles were expressed as percentages of the lunge with no load exercise condition. Additionally, the sequence of muscle activation was visually determined for the single limb Skorcher with no load and the rapid treadmill run exercises. The onset of muscle contraction relative to the beginning of a repetition or cycle were ranked from one to four in order from earliest (1) to latest (4) using a custom analysis program (Matlab).

References

Hoppenfeld, S. (1976). *Physical Examination of the Spine and Extremities*. Upper Saddle River, NJ: Prentice Hall.

Konrad, P. (2005). *The ABC of EMG*. Noraxon, Inc., USA.

Wojtys, E. M., Wylie, B. B., & Huston, L. J. (1996). The effects of muscle fatigue on neuromuscular function and anterior tibial translation in healthy knees. *American Journal of Sports Medicine*, *24*, 615-621.

Table 1. Participant Information

No.	Height (ft-in)	Height (m)	Weight (lbs)	Mass (kg)	Age	Sex	Activity Level*	Shoe Size	Dominant Side	Run Speed (mph)	Run Speed (m/s)
1	5-9	1.75	141	64	35	M	4	M 9.5	R	9.4	4.20
2	5-2	1.57	136	62	38	F	0	W 6.5	R	4.0	1.79
3	6-2	1.88	268	122	35	M	4	M 13	R	6.8	3.04
4	5-7	1.70	175	80	35	M	0	M 8	R	8.4	3.75
5	6-0	1.83	224	102	34	M	4	M 11	L	9.1	4.06
6	5-6	1.68	122	55	29	F	6	W 7	R	8.4	3.75
7	6-0	1.83	236	107	30	M	2	M 12	R	8.5	3.79
8	5-9	1.75	145	66	46	M	2	M 10	R	9.0	4.02
9	6-2	1.88	211	96	35	M	8	M 11.5	R	9.0	4.02
10	5-7	1.70	185	84	41	M	0	M 9	R	8.7	3.88
M		**1.76**	**184**	**83.8**	**36**		**3.0**			**8.1**	**3.6**
SD		**0.10**	**49.1**	**22.3**	**5.0**		**2.7**			**1.6**	**0.7**

***Physical Activity Level Scale**

Level	Activity
10	Competitive jumping, turning, twisting sports
8	Recreational jumping, turning, twisting sports
6	Jog, bike, swim, occasional pivoting sports
4	No jumping, turning, twisting sports; swim, bike, jog regularly
2	No jumping, turning, twisting sports; occasionally jog, swim, bike
0	Inactive, sedentary

Wojtys et al (1996)

TABLE 2. Descriptive Statistics.

Exercise	Statistic	Adductor Longus	Biceps Femoris	Gluteus Maximus	Rectus Femoris
Deadlift45	*M*	73	147	93	87
	SD	11.8	38.9	22.6	25.7
DLSkor45	*M*	102	334	236	24
	SD	23.5	91.1	99.4	9.6
Squat45	*M*	75	112	77	122
	SD	17.6	41.4	19.4	34.7
Lunge0	*M*	100	100	100	100
	SD	0.0	0.0	0.0	0.0
SLSkor0	*M*	183	575	302	38
	SD	65.8	122.3	94.3	14.5

Values are percent of the Lunge0 exercise. N=10 participants and average of 5 repetitions. 45 and 0 indicate the external load used during the exercise.

TABLE 3. Rank Order of All Exercises by Muscle.

Exercise	Adductor Longus	Biceps Femoris	Gluteus Maximus	Rectus Femoris	Avg Rank	Final Assigned Rank
Deadlift45	5	3	4	3	**3.8**	**5**
DLSkor45	2	2	2	5	**2.8**	**2**
Squat45	4	4	5	1	**3.5**	**4**
Lunge0	3	5	3	2	**3.3**	**3**
SLSkor0	1	1	1	4	**1.8**	**1**

45 and 0 indicate the external load used during the exercise.