THE EFFECTS OF ROPE SKIPPING ON MOVEMENT CO-ORDINATION IN CHILDREN - AN ELECTROMYOGRAPHIC STUDY

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KEY WORDS: rope skipping, EMG, co-ordination, children

INTRODUCTION: The issue of rope skipping as a method of fitness training is highly relevant to the community. A daily 10 minutes workout of rope skipping was found to be as good as 30 minutes of jogging a day (Tibor et al. 1986). Studies on rope skipping focus on energy expenditure (Glenn et al. 1980), working intensity (William et al. 1981), or movement kinematics (John et al. 1986). Information about EMG responses during rope skipping is lacking. Little is known about the effects of rope skipping on movement co-ordination in children. The purpose of this study was to examine the effects of eight weeks of rope skipping exercise on the movement co-ordination in school children in terms of EMG responses of some involved muscle groups.

METHODS: Subjects Twenty male Form 5 school students who did not have rope skipping experience were randomly recruited from a secondary school and formed paired exercise group and control group, in accordance with the Body Mass Index. All subjects were healthy and without any disorders of the musculoskeletal system. The age, body height and body weight for the exercise group were 15.60±0.52 years, 173.83±5.05 cm and 59.93±5.73 kg and for the control group were 15.70±0.68 years, 170.28±6.05 cm and 55.20±6.49 kg respectively.
Exercise The subjects in the exercise group took part in rope skipping for 8 weeks, 5 times weekly, twenty minutes each time, and at an intensity that produced a mean heart rate of an estimated 75% of maximal oxygen intake. The subjects in the control group did not participate in any programmed exercise except the physical education courses offered by the school for all students.
Testing Arrangement Two testing sessions were arranged for both groups: one week before and one week after the training program. In each session, the subjects were asked to perform rope skipping in the two-leg form for 10 minutes at a rate that induced the heart rate of each subject to reach its maximal value. During the testing, the remote EMG signals of eight muscles in the leg were detected. The selected muscles were the vastus medialis, rectus femoris, vatus lateralis, tibialis anterior, semitendinosus, biceps femoris and gastrocnemius.
Electromyography To collect EMG signals, surface electrodes (silver / silver chloride, ARBO Medizin-Technologie, Germany) were mounted on the selected muscles in a standardized manner; in the direction of the muscle fibers, with an inter-electrode distance of 3 cm. Before mounting electrodes, the skin was shaved and rubbed with alcohol in order to lower the skin resistance. After mounting the electrodes on the skin, the electrode cables were connected to the electrodes in a described sequence at one end, and connected with the pre-amplifier, which is close to the pads and permits completely eliminating the artifacts caused by patient movements, at the other end. The pre-amplifier is fixed on the skin with paper

adhesive tearable tape (Albupore, Smith+Nephew) to prevent the vibration of the amplifier.
Signals form the electrodes are pre-amplified, transmitted by telemetric radio transmitters (915 Transmitter Unit, TELEMG, Italy) and received by the receiving unit (920 Diversity Data Receiver, TELEMG). The received signals then pass through the optical fiber to the main unit. The main unit amplifies the signal by 1000.
Full-wave rectified, low-pass filtered (600 Hz) and high-pass filtered (10 Hz) ENG signals were recorded. All signals were simultaneously displayed on an oscilloscope (KENWOOD CS-5260) connected in parallel. This was used particularly to test the electrode function.
Data Analysis. The collected EMG signals were full-wave rectified. The time duration for each muscle contraction, the sequence of the muscle contractions and the timing of different contractions were quantitatively determined. All data were tested with the t-test to identify any differences in muscle co-ordination between the trained and untrained groups. The EMG signal analyzed was related to the phase: starting of landing and then jumping.

RESULTS AND DISCUSSION: Table 1 shows the mean and standard deviations of the duration of contraction of different muscles. In this study, the instant the Vastus medialis began to contract was selected as a reference point for assessing the contraction timing of other muscles. A significant difference was found in the duration of vastus medialis contractions between the trained and untrained rope skippers with $p<.001$ (Table 2).

Table 1. Means and standard deviations of duration of muscle contraction

Muscle group	Trained rope skipper		Untrained rope skipper	
	Mean (ms)	SD	Mean (ms)	SD
Vastus medialis	202.8	32.6	285.9	95.8
Rectus femoris	250.2	76.8	297.5	96.0
Vatus lateralis	210.0	44.9	247.2	89.2
Tibialis anterior	208.4	99.6	368.4	102.9
Semitendinosus	275.5	116.9	287.6	124.8
Biceps femoris	315.7	134.8	316.1	132.9
Gastrocnemius	283.0	78.9	355.6	131.5

Table 2. Different between the duration of Vastus medialis contraction

Muscle group	Trained rope skipper		Untrained rope skipper			
	Mean (ms)	SD	Mean (ms)	SD	F	*P*
Vastus medialis	202.8	32.6	285.9	95.8	17.031	.001

The timing difference between some selected muscles are shown in Table 3. The timing difference of vastus medialis and tibialis anterior showed significant differences between the two groups with $p<.001$. There was also a significant difference in timing of the muscles rectus femoris and tibialis anterior, vatus lateralis and tibialis anterior, and gastrocnemius and tibialis anterior between the trained and untrained groups with *p*<.01.

Table 3 Different in contraction timing between certain muscle groups

Muscle group		Trained rope skipper		Untrained rope skipper			
Early	Later	TD (ms)	SD	TD (ms)	SD	F	*p*
Vastus medialis	Tibialis anterior	73.7	92.5	5.1	20.7	18.2	.001
Rectus femoris	Tibialis anterior	76.2	91.2	7.8	26.8	11.8	.01
Vatus lateralis	Tibialis anterior	132.2	168.6	5.3	25.5	12.9	.01
Tibialis anterior	Gastrocnem-ius	114.6	96.3	19.6	34.1	13.4	.01

TD : Timing Differences

DISCUSSION: Controlling for the frequency and style of rope skipping, EMG signals were collected. The EMG signal was calculated from the beginning of landing and throughout the consecutive jumping. The durations of muscle contractions were compared between trained and untrained rope skippers. Moreover, the timing differences of the contraction of different muscles were calculated and used to compare whether there was a difference between the two groups of rope skippers.

The vastus medialis contraction had shorter duration in the group of trained rope skippers than in the other. The shorter duration of the EMG signal reflects the fact that the working time of the muscle is shorter. When compared with the same intensity of exercise, shorter muscle working time may result in lower energy expenditure.

Co-ordination of different muscles in contraction to execute an exercise is of vital importance. The better the muscle co-ordination, the better the exercise performance.

At the beginning of landing, the tibialis anterior starts to contract eccentrically. When jumping-up begins, the gastrocnemius and quadriceps (vastus medialis, rectus femoris and vatus lateralis) undergo a concentric contraction (John et al. 1986).

With the same frequency of skipping, significant differences were found in muscle contraction timing between trained and untrained rope skippers. The trained rope skippers demonstrated greater time periods in muscle contractions between the quadriceps (vastus medialis, rectus femoris and vatus lateralis) and tibialis anterior when jumping up. The contraction timing between the tibialis anterior at landing and the gastrocnemius at jumping showed greater time periods in the trained group.

It is well known that the shorter muscle contraction durations and greater time periods between different muscle contractions in performing an exercise task can provide more resting time to the involved muscles, resulting in less energy expenditure. This advantage was found in the subject group of trained rope skippers. It indicated that the trained rope skipper possessed better co-ordination capacity in muscle contraction and higher working efficiency in performing rope skipping.

CONCLUSION: This study compared the EMG responses of selected muscles on the legs between the rope skipping trained and untrained subjects under the rope skipping tests with the same frequency. Results showed that after 8 weeks rope skipping exercise, the trained subjects demonstrated shorter muscle working time and greater time gap between the consecutive contraction of muscles than the untrained subjects, indicating lower energy expenditure and better movement co-ordination characteristics. A programmed rope skipping exercise can improve movement co-ordination ability in children.

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