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European Journal of Physical Education and Sport Science
ISSN: 2501 - 1235
ISSN-L: 2501 - 1235
Available on-line at: www.oapub.org/edu

doi: 10.5281/zenodo.1247996 Volume 4 | Issue 6 | 2018

EFFECT OF A 6 WEEK AGILITY TRAINING PROGRAM ON LOWER BODY MUSCLE ELECTROMYOGRAPHY CHANGES OF INDIAN TAEKWONDO PLAYERS

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Abstract:
Purpose: Taekwondo requires high level of agility, lower limb strength as it helps to improve performance in activities that require you to change direction quickly while keeping balance, strength, speed and body control. The purpose of the study was to determine the effect of a 6 week agility training program on lower body muscle electromyography changes. **Methodology:** 30 elite national level taekwondo players volunteered and were randomly assigned into two groups, group 1 (G1; n = 15) agility training group (mean age 19.60 ± 2.06 years; mean height 1.72 ± 0.08 m; mean mass 57. 94 ± 10. 27 kg) and group 2 (G2; n = 15) control group (mean age 20.13 ± 1.55; mean height 1.71 ± 0.07 m; mean mass 65.19 ± 16.87). Both agility training group and control group were assessed for electromyography of lower limb muscles by Noraxon Telemyo U.S.A., Inc.v3.1.10. Control group had followed their routine training schedule, and agility training group had performed agility training for 6 weeks. After 6 weeks of training post measures were taken. **Result:** Significant changes ($p < 0.05$) were observed in average mean amplitude and maximum of the left biceps femoris muscle as well as some specific findings were observed. **Conclusion:** This program can be incorporated to

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improve overall performance in the athletes and can beneficial for athletes who require quick movements while performing their sport such as taekwondo.

Keywords: agility, taekwondo, electromyography, biceps femoris, telemetric

1. Background

The word "taekwondo" is derived from the Korean word: "Tae" means "to kick" or "Smash with the feet," "Kwon" implies "punching" or "destroying with the hand or fist," and "Do" means "way" or "method."[1]Taekwondo thus is the technique of unarmed combat for self-defense that involves the skillful application of techniques including punching; jumping kicks, blocks, dodges; and parrying actions with hands and feet. Taekwondo is a combat sport emphasizing on kicking techniques and dynamic footwork. Taekwondo is a martial art that in "today" form of self-defense has evolved by combining many different styles of martial arts that existed in Korea. Taekwondo and other martial art games have a direct link to agility, rhythm, reaction time, and balance because it requires defense against attack from all directions using both sides of their body. Agility has classically been defined simply not only the ability to change direction rapidly [2] but also the ability to change direction rapidly and accurately.[3] A new definition of agility is proposed by Sheppard and Young, 2006[4] as "a rapid whole-body movement with change of velocity or direction in response to a stimulus" which has relationships with trainable physical qualities such as strength, power, and technique, as well as cognitive components such as visual scanning techniques, visual scanning speed, and anticipation.

Agility testing is generally confined to tests of physical components such as change of direction, speed, or cognitive components such as anticipation and pattern recognition. Agility training is thought to be a re-enforcement of motor programming through neuromuscular conditioning and neural adaptation of muscle spindle, Golgi-tendon organs, and joint proprioceptors.[5],[6],[7] Performance is often dependent on the athlete's jumping ability during offensive and defensive skills.[8]

The multidimensional movement demands of field and court games dictate a revaluation of the traditional approach to the development of agility. This demands a systematic multifactored approach that results in significant improvement in game speed. Full development of coordinative abilities provides a range of motor skills that can be adapted to deal with sport specific movement demands.[9]

Therefore, the purpose of the study was to determine the effect of a 6-week agility training program on agility, anaerobic power, reaction time, balance, and flexibility of Indian taekwondo players.

2. Procedure

Thirty elite national level taekwondo players (mean age 19.86 ± 1.81 years; mean height 1.70 ± 07 m; mean mass 60.36 ± 13.74 kg) volunteered and were randomly assigned into two groups, Group 1 (G1; *n* = 15) agility training group and Group 2 (G2; *n* = 15) control group. All testing and training procedures, benefits, and potential risks of the study were explained to the participants before signing the informed consent form and starting the test. "This study was approved by the Institutional Ethics Committee of Faculty of Sports Medicine and Physiotherapy, Guru Nanak Dev University, Amritsar. Each participant voluntarily provided written informed consent before participating." The inclusion criteria included the following: participants agreed with the purpose of this study, participants had no existing musculoskeletal problems such as lower limb fracture and sprain/strain, participants had no recent injury to lower limb, and participants had no existing medical problems.

The participants of the study were randomly divided into two groups: Group 1 (G1; *n* = 15) agility training group and Group 2 (G2; *n* = 15) control group. All participants agreed not to change or increase their current exercise habits during the course of the study. The agility training group participated in a 6-week exercise program performing a variety of agility exercises designed [Table 1],[10] while the control group followed their routine training schedule. The agility training group performed a 5-min warm-up protocol consisting of general stretching, high knees, heel-ups, and carioca drill before each session. Participants were tested before and after the 6-week training period. The procedure was conducted using the telemetric Noraxon TELEMYO U.S.A., Inc.v3.1.10 machine. The readings of total 10 muscles (5 on each side was taken) which include the rectus femoris, biceps femoris (long head), medial gastrocnemius, soleus and tibialis anterior muscle .The readings were taken in the position of subject standing. The procedure was conducted before and after for all the subjects as shown in figures 1-3.

The below described is the 6-week agility training protocol:

Table 1: 6 –Week Exercise Program performed by the Subjects in The Agility Group

Time Session	Agility Training	Set/Repetitions
Week 1 [Day 1-3]	1. 20 - Yard Shuttle 2. 30 - Yard T – Drill 3. Squirm 4. 40 – Yard Sprint 5. 40 – Yard Backpedal - Forward	3 Sets of 10 Repetitions
Week 2 [Day 4-6]	Same as Week 1	5 Sets of 10 Repetitions
Week 3 [Day 7-9]	1. 40 –Yard Square – Carioca 2. 15- Yard Turn Drill 3. Figure Eights 4. Z – Pattern Run 5. Zigzag	3 Sets of 10 Repetitions
Week 4 [Day 10-12]	Same as Week 3	5 Sets of 10 Repetitions

Week 5 [Day 13-15]	1. 40 –Yard Square Drill -*Sprint, Single-Leg Hop , Backpedal* 2. Star Drill – *Sprint, Backpedal ,Shuffle* *3.* Five-Cone Snake Drill *4.* 180- Degree Turn *5.* Crossover Shuffle	3 Sets of 10 Repetitions
Week 6 [Day 16-18]	Same as Week 5	5 Sets of 10 Repetitions

Epley, B. (2004). The path to athletic power: The model conditioning program for championship performance. Human Kinetics.

Figure 1: E.MG. Changes monitored on the screen

Figure 2

Figure 3

Figure 2 and 3 show the placements of the electrodes.

3. Results

Table 2: Description of mean values of Averaged Mean Amplitude of All Periods [RT TIB.ANT., uV]

Unpaired T Test	**Averaged Mean Amplitude of All Periods [RT TIB.ANT., uV]**			
	Pre Readings		**Post Readings**	
	Group A (Agility Training)	**Group B (Control)**	**Group A (Agility Training)**	**Group B (Control)**
Mean	-0.37	-0.42	-0.46	-0.36
S.D.	0.18	0.46	0.17	0.39
p value	0.68		0.39	

Table 3: Description of mean values of Averaged Mean Amplitude of All Periods [LT TIB.ANT., uV]

Unpaired T Test	**Averaged Mean Amplitude of All Periods[LT TIB.ANT., uV]**			
	Pre Readings		**Post Readings**	
	Group A (Agility Training)	**Group B (Control)**	**Group A (Agility Training)**	**Group B (Control)**
Mean	-0.55	-0.73	-0.40	-0.39
S.D.	0.13	0.56	0.87	0.54
p value	0.22		0.95	

Table 4: Description of mean values of Averaged Mean Amplitude of All Periods [RT MED. GASTRO, uV]

Unpaired T Test	**Averaged Mean Amplitude of All Periods [RT MED. GASTRO, uV]**			
	Pre Readings		**Post Readings**	
	Group A (Agility Training)	**Group B (Control)**	**Group A (Agility Training)**	**Group B (Control)**
Mean	-0.47	-0.46	-0.47	-0.46
S.D.	0.143	0.259	0.20	0.21
p value	0.99		0.89	

Table 5: Description of mean values of Averaged Mean Amplitude of All Periods [LT MED. GASTRO, uV]

Unpaired T Test	**Averaged Mean Amplitude of All Periods [LT MED. GASTRO, uV]**			
	Pre Readings		**Post Readings**	
	Group A (Agility Training)	**Group B (Control)**	**Group A (Agility Training)**	**Group B (Control)**
Mean	-0.41	-0.64	-0.07	-0.43
S.D.	0.11	0.22	1.12	0.26
p value	0.00		0.22	

Table 6: Description of mean values of Averaged Mean Amplitude of All Periods [RT RECTUS FEM., uV]

Unpaired T Test	Averaged Mean Amplitude of All Periods [RT RECTUS FEM., uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	-0.34	-0.46	-0.41	-0.20
S.D.	0.29	0.66	0.12	0.47
p value	0.52		0.11	

Table 7: Description of mean values of Averaged Mean Amplitude of All Periods [LT RECTUS FEM., uV]

Unpaired T Test	Averaged Mean Amplitude of All Periods [LT RECTUS FEM., uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	1.47	-0.29	-0.18	-0.53
S.D.	7.37	0.35	0.60	0.33
p value	0.36		0.05	

Table 8: Description of mean values of Averaged Mean Amplitude of All Periods [RT BICEPS FEM.uV]

Unpaired T Test	Averaged Mean Amplitude of All Periods [RT BICEPS FEM., uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	-0.46	-0.50	-0.32	-0.29
S.D.	0.15	0.20	0.47	1.00
p value	0.59		0.91	

Table 9: Description of mean values of Averaged Mean Amplitude of All Periods [LT BICEPS FEM., uV]

Unpaired T Test	Averaged Mean Amplitude of All Periods [LT BICEPS FEM., uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	-0.39	-0.39	-0.27	-0.47
S.D.	0.08	0.22	0.27	0.24
p value	0.95		0.04	

Table 10: Description of mean values of Averaged Mean Amplitude of All Periods [RT SOLEUS, uV]

Unpaired T Test	Averaged Mean Amplitude of All Periods[RT SOLEUS, uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	-0.50	-0.42	-0.22	-0.32
S.D.	0.16	0.15	0.48	0.34
p value	0.16		0.51	

Table 11: Description of mean values of Averaged Mean Amplitude of All Periods [LT SOLEUS, uV]

Unpaired T Test	Averaged Mean Amplitude of All Periods[LT SOLEUS, uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	-0.45	-0.38	-0.32	-0.24
S.D.	0.10	0.28	0.46	0.29
p value	0.41		0.55	

Table 12: Description of mean values of Averaged Max of All Periods [RT TIB. ANT., uV]

Unpaired T Test	Averaged Max of All Periods[RT TIB.ANT., uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	88.21	95.79	72.07	153.47
S.D.	71.36	99.43	63.55	186.85
p value	0.81		0.12	

Table 13: Description of mean values of Averaged Max of All Periods [LT TIB.ANT., uV]

Unpaired T Test	Averaged Max of All Periods[LT TIB.ANT., uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	88.97	66.23	248.23	138.07
S.D.	57.78	59.82	542.80	122.57
p value	0.29		0.45	

Table 14: Description of mean values of Averaged Max of All Periods [RT MED. GASTRO, uV]

Unpaired T Test	Averaged Max of All Periods[RT MED. GASTRO, uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	144.39	290.16	140.82	183.89
S.D.	64.32	409.52	81.62	154.68
p value	0.18		0.34	

Table 15: Description of mean values of Averaged Max of All Periods [LT MED. GASTRO, uV]

Unpaired T Test	Averaged Max of All Periods[LT MED. GASTRO, uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	106.89	154.90	136.27	649.76
S.D.	90.65	96.74	164.98	1123.34
p value	0.17		0.09	

Table 16: Description of mean values of Averaged Max of All Periods [RT RECTUS FEM., uV]

Unpaired T Test	Averaged Max of All Periods[RT RECTUS FEM., uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	184.28	137.67	98.11	87.61
S.D.	442.36	230.32	137.11	74.39
p value	0.72		0.79	

Table 17: Description of mean values of Averaged Max of All Periods [LT RECTUS FEM., uV]

Unpaired T Test	Averaged Max of All Periods[LT RECTUS FEM., uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	429.30	130.72	58.23	705.85
S.D.	1298.48	289.86	60.03	2022.63
p value	0.39		0.22	

Table 18: Description of mean values of Averaged Max of All Periods [RT BICEPS FEM., uV]

Unpaired T Test	Averaged Max of All Periods[RT BICEPS FEM., uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	48.24	52.87	67.21	221.25
S.D.	42.52	46.62	134.16	422.51
p value	0.77		0.18	

Table 19: Description of mean values of Averaged Max of All Periods [LT BICEPS FEM., uV]

Unpaired T Test	Averaged Max of All Periods[LT BICEPS FEM., uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	52.33	49.13	31.29	77.35
S.D.	42.06	35.38	18.60	40.96
p value	0.82		0.00	

Table 20: Description of mean values of Averaged Max of All Periods [RT SOLEUS, uV]

Unpaired T Test	Averaged Max of All Periods[RT SOLEUS, uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	169.44	157.60	144.93	233.99
S.D.	140.62	88.24	122.88	157.60
p value	0.78		0.09	

Table 21: Description of mean values of Averaged Max of All Periods [LT SOLEUS, uV]

Unpaired T Test	Averaged Max of All Periods[LT SOLEUS, uV]			
	Pre Readings		Post Readings	
	Group A (Agility Training)	Group B (Control)	Group A (Agility Training)	Group B (Control)
Mean	127.97	164.03	143.42	120.79
S.D.	88.59	155.64	79.38	67.52
p value	0.44		0.40	

4. Discussion

In the present study the dynamic electromyography of tibialis anterior, medial gastrocnemius, rectus femoris, biceps femoris, soleus muscles bilaterally was measured which mainly included the averaged mean amplitude of all periods and averaged maximum of all periods in uV(microvolt) bilaterally. In the present study, significant differences were seen in the experimental group for the left biceps femoris muscle for the average mean and maximum values for all periods. Rezaimanesh, Amiri-Farsani, & Saidian, 2011 in their study observed that 6 weeks of isotonic training had a significant effect on the electromyography of the biceps femoris while performing the squat movement but the electromyography for the biceps femoris was insignificant in the vertical jump which was in accordance to the results of our study in which changes were seen in the left biceps femoris muscle. The authors studied and stated that the nature and type of isotonic exercises add much force and tension to muscle cords. Performing such activities or tolerating extreme force and tension may lead to needed physiological or biological changes in muscle cords and other parts of the contraction system and can also cause muscle electromyography changes to rise. This can be a possible reason for the findings in the present study. Study done by Davar Rezaeimanesh, 2011 on volleyball players stated otherwise that that 6 weeks of isotonic training in 4 weekly sessions caused no significant increase in the muscle electromyography of the biceps femoris when performing the vertical jump (explosive power) which tends to oppose the findings in the present study. The cause can be noted as insufficient training specific to the muscle or the insufficiency in the severity of training. Kerrigan & Casey, 2005 had concluded that the electromyography system is used to record the activity of muscles during gait, process referred to as dynamic electromyography the process is relatively safe and effective, the procedure adds significantly to complexity of gait analysis. In other study, the author investigated lower extremity neuromuscular activity patterns during gait transitions with continuously changing locomotion speeds. Muscular activities related to gait transitions (walk to run and run to walk) induced by changing treadmill speed were compared to muscular activities during walk and run at constant speeds (Li & Ogden, 2012). The changes observed in the results obtained were that the peak magnitudes of gluteus maximus, rectus femoris, gastrocnemius and soleus increased on to a high level as locomotion approached walk to run transition within the last five steps which does not support the results of the present study in which changes were not seen in the other muscles apart from left biceps femoris muscle bilaterally. In a previous study, the authors inferred that electromyography signal has quite often been used as an assessment of muscle fatigue and the increase in amplitude of the electromyography signal as an empirical measure of localized muscle fatigue or as an indicator of muscle fatigue. (Dimitrov & Dimitrov, 2002)

Therefore, in our study, participants who underwent agility training were able to improve their physical variables significantly. We found a positive relationship between agility training and improvements of the variables. This improvement in agility is beneficial for athletes who require quick movements while performing their sport such as taekwondo. Regular participation in an agility training program can improve measures of various variables associated with the sport.

5. Conclusion

The results from our study are very encouraging and demonstrate that the benefits agility training can have on performance. Not only can players use agility to break the monotony of training, but they can also improve their specific skills while working to become more agile. In addition, our results support that improvements in agility can occur in as little as 6 weeks of agility training which can be useful during the last preparatory phase before in-season competition for taekwondo players. Based on these findings, the Indian taekwondo players can show significant improvement in the above stated parameters after 6 weeks of agility training.

Acknowledgment
The authors are thankful of their participants. Dr. Amrinder Singh planned the study and submitted the study. Abhinav Sathe conducted the study. Dr Jaspal Singh Sandhu provided the set-up for the study the set-up was organized by the Department of Sports Medicine and Physiotherapy, Guru Nanak Dev University Amritsar, Punjab (India).

Financial support and sponsorship
The set-up was organized by the Department of Sports Medicine and Physiotherapy, Guru Nanak Dev University Amritsar, Punjab, India.

Conflicts of interest
There are no conflicts of interest.

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