# Effect of a 6-week agility training program on lower limb isometric strength and fatigue index of indian taekwondo players

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**Background**
Taekwondo is a martial art sport requiring high level of agility and lower limb strength as it helps improve performance in activities. The purpose of the study was to determine the effect of a 6-week agility training program on lower limb isometric strength and fatigue index of Indian taekwondo players.

**Materials and methods**
A total of 30 elite national-level taekwondo players (mean age: 19.86±1.81 years, mean height: 1.70±7 m, and mean mass: 60.36±13.74 kg) volunteered and were randomly assigned into two groups: group 1 ($n$=15) agility training group and group 2 ($n$=15) control group. Both agility training group and control group were assessed for lower limb isometric strength and fatigue index assessed by HUR 5340 leg extension/curl computer controlled isotonic/isometric dynamometer. 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-training measures were taken.

**Results**
Significant changes ($P<0.05$) in group 1 (agility training group) were observed in all the variables tested. No significant changes/decline in performance was found in group 2 group (control group).

**Conclusion**
This program significantly improved the performance and may be implemented as a regular part of the training schedule.

**Keywords:**
agility, fatigue index, isometric strength, performance, taekwondo

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## Introduction

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, 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’s’ 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 the body.

Agility has classically been defined simply as ‘the ability to change direction rapidly’ [2], and also as ‘the ability to change direction rapidly and accurately’ [3]. A new definition of agility is proposed by Sheppard *et al.*[4] ‘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 test 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 adaptations of muscle spindles, Golgi–tendon organs, and joint proprioceptors [5–7]. Performance is often dependent upon the athlete’s jumping ability during offensive and defensive skills [8].

The multidimensional movement demands of field and court games dictate a re-evaluation of the traditional approach to the development of agility. This demands a systematic multifactored approach that results in significant improvement in speed of the game. Full development of coordinative abilities provides a range of strength and endurance that can be adapted to deal with movement demands according to specific sports [9].

Therefore, the purpose of the study was to determine the effect of a 6-week agility training program on lower limb isometric strength and fatigue index (FI) of Indian taekwondo players.

## Materials and methods

A total of 30 elite national-level taekwondo players (mean age: 19.86±1.81 years, mean height: 1.70±7 m, and mean mass: 60.36±13.74 kg) volunteered and were randomly assigned into two groups: group 1 ($n$=15) agility training group and group 2 ($n$=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.

All participants had agreed not to change or increase their current exercise routine during the complete course of the study. The agility training group participated in a 6-week exercises program performing a variety of agility exercises designed (Table 1), whereas 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 drills before each session. Participants were tested before and after the 6-week training period for lower limb isometric strength and FI assessed by HUR 5340 leg extension/curl computer controlled isotonic/isometric dynamometer (®HUR, Kokkola, Finland).

## Results

Calculated value, 6.75, is more than the table value at 5% level of significance with *d.f.* of 28, i.e. 2.04. There is significant difference between the experimental and control group regarding the variable agility (Tables 2–9).

## Discussion

Anticipation, decision making, and quick responses are important skills that taekwondo players need to maximize their performance. The program at the start of the study was designed to increase an athlete's overall aspects and to allow them time for mental preparation of the effort required. Milner-Brown *et al*. [11] conducted a study to examine the physiologic methods developed to objectively quantify muscle strength, endurance, and fatigability. In the study, isometric force and rectified/integrated electromyogram were simultaneously recorded during the three phases of a recording session: (a) prefatigue, (b) fatigue (1-min duration), and (c) postfatigue recovery (≤10 min). Five parameters of muscle performance were computed: (a) maximum force exerted during isometric voluntary contraction (muscle strength), (b) force-time integral area under

**Table 1 Six-week agility training protocol**

| Time session | Agility training | Set/repetitions |
|---|---|---|
| Week 1 (day 1–3) | | |
| | 20-yard shuttle | 3 sets of 10 repetitions |
| | 30-yard turn drill | |
| | Squirm | |
| | 40-yard sprint | |
| | 40-yard backpedal – Forward | |
| Week 2 (day 4–6) | Same as week 1 | 5 sets of 10 repetitions |
| Week 3 (day 7–9)] | 40-yard square – carioca | 3 sets of 10 repetitions |
| | 15-yard turn drill | |
| | Figure 8 | |
| | Z-pattern run | |
| | Zigzag | |
| Week 4 (day 10–12)] | Same as week 3 | 5 sets of 10 repetitions |
| Week 5 (day 13–15) | 40-yard square drill – sprint, single leg hop, and backpedal | 3 sets of 10 repetitions |
| | Star drill – sprint, backpedal, and shuffle | |
| | Five-cone snake drill | |
| | 180° turn | |
| | Crossover shuffle | |
| Week 6 (day 16–18) | Same as week 5 | Sets of 10 repetitions |

Epley [10].

**Table 2 Description of fatigue index (right leg) in extension**

| Unpaired *t*-test | Pretraining readings | | Post-training readings | |
|---|---|---|---|---|
| | Fatigue index (right leg) in extension | | Fatigue index (right leg) in extension | |
| | Group A (agility training) | Group B (control) | Group A (agility training) | Group B (control) |
| Mean | 30.04 | 31.14 | 40.52 | 29.13 |
| SD | 9.92 | 14.33 | 17.18 | 15.07 |
| Unpaired *t*-test | 0.24 | | 1.93 | |
| *P* value | 0.80 | | 0.06 | |
| Table value at 0.05 significance level with *d.f.* 28 | 2.05 | | 2.04 | |
| Result | Nonsignificant | | Significant | |

**Table 3 Description of fatigue index (left leg) in extension**

| Unpaired *t*-test | Pretraining readings | | Post-training readings | |
|---|---|---|---|---|
| | Fatigue index (left leg) in extension | | Fatigue index (left leg) in extension | |
| | Group A (agility training) | Group B (control) | Group A (agility training) | Group B (control) |
| Mean | 31.11 | 29.81 | 39.65 | 27.94 |
| SD | 15.62 | 14.52 | 18.22 | 11.97 |
| Unpaired *t*-test | 0.23 | | 2.08 | |
| *P* value | 0.81 | | 0.04 | |
| Table value at 0.05 significance level with *d.f.* 28 | 2.05 | | 2.04 | |
| Result | Nonsignificant | | Significant | |

**Table 4 Description of fatigue index (right leg) in flexion**

| Unpaired *t*-test | Pretraining readings | | Post-training readings | |
|---|---|---|---|---|
| | Fatigue index (right leg) in flexion | | Fatigue index (right leg) in flexion | |
| | Group A (agility training) | Group B (control) | Group A (agility training) | Group B (control) |
| Mean | 24.85 | 27.50 | 43.62 | 25.59 |
| SD | 11.35 | 13.08 | 15.24 | 11.64 |
| Unpaired *t*-test | 0.59 | | 3.64 | |
| *P* value | 0.55 | | 0.00 | |
| Table value at 0.05 significance level with *d.f.* 28 | 2.05 | | 2.04 | |
| Result | Nonsignificant | | Significant | |

force-time plot (endurance), (c) FI (% reduction in maximum force, (d) neuromuscular efficiency (force/mv of emg recruited), and (e) recovery time. The results indicated that the neuromuscular efficiency decreased significantly at the end of the fatigue phase; it generally increased to the prefatigue level in 2–10 min, during the recovery phase. In the present study, the isometric strength and FI were measured in which significant differences were seen in the FI of left leg in extension as well as in flexion and in the right leg for flexion. The findings of this study also found that agility training improved FI (left leg) in extension from 31.11±15.62 to 39.65±18.22 ($P<0.001$), FI (right leg) in flexion from 24.85±11.35 to 43.62±15.24 ($P<0.001$), FI (left leg) in flexion from 25.08±10.02 to 43.53±13.46 ($P<0.001$), best right extension: best left extension from 0.98±0.13 to 1.10±0.19 ($P<0.001$), and best right flexion: best left flexion from 0.91±0.15 to 1.06±0.25 ($P<0.001$). Significant differences were also seen in the best right extension to best left extension ratio as well as the flexion ratio. Milner-Brown *et al.* [11] indicated in their study that the neuromuscular efficiency decreased significantly at the end of the fatigue phase; it generally increased to the prefatigue level in 2–10 min, during the recovery phase which was in accordance to the results of the present study. The analysis of the knee isometric strength and FI was in accordance with Surakka *et al.* [12] who conducted a study to investigate the intrarater and inter-rater reliability of maximal knee muscle strength and fatigue measurements in healthy participants, and the results of their study also indicated that isometric torque of knee extensors and

**Table 5 Description of mean values of fatigue index (left leg) in flexion**

| Unpaired *t*-test | Pretraining readings | | Post-training readings | |
|---|---|---|---|---|
| | Fatigue index (left leg) in flexion | | Fatigue index (left leg) in flexion | |
| | Group A (agility training) | Group B (control) | Group A (agility training) | Group B (control) |
| Mean | 25.08 | 25.26 | 43.53 | 27.06 |
| SD | 10.02 | 14.15 | 13.46 | 15.37 |
| Unpaired *t*-test | 0.04 | | 3.12 | |
| *P* value | 0.96 | | 0.00 | |
| Table value at 0.05 significance level with *d.f.* 28 | 2.05 | | 2.04 | |
| Result | Nonsignificant | | Significant | |

**Table 6 Description of best extension: best flexion (right leg)**

| Unpaired *t*-test | Pretraining readings | | Post-training readings | |
|---|---|---|---|---|
| | Best extension: best flexion (right leg) | | Best extension: best flexion (right leg) | |
| | Group A (agility training) | Group B (control) | Group A (agility training) | Group B (control) |
| Mean | 0.54 | 0.59 | 0.58 | 0.50 |
| SD | 0.13 | 0.20 | 0.15 | 0.17 |
| Unpaired *t*-test | 0.93 | | 1.31 | |
| *P* value | 0.35 | | 0.19 | |
| Table value at 0.05 significance level with *d.f.* 28 | 2.05 | | 2.05 | |
| Result | Nonsignificant | | Nonsignificant | |

**Table 7 Description of best extension: best flexion (left leg)**

| Unpaired *t*-test | Pretraining readings | | Post-training readings | |
|---|---|---|---|---|
| | Best extension: best flexion (left leg) | | Best extension: best flexion (left leg) | |
| | Group A (agility training) | Group B (control) | Group A (agility training) | Group B (control) |
| Mean | 0.50 | 0.55 | 0.54 | 0.54 |
| SD | 0.13 | 0.17 | 0.12 | 0.23 |
| Unpaired *t*-test | 0.88 | | 0.02 | |
| *P* value | 0.38 | | 0.97 | |
| Table value at 0.05 significance level with *d.f.* 28 | 2.05 | | 2.05 | |
| Result | Nonsignificant | | Nonsignificant | |

**Table 8 Description of best right extension: best left extension**

| Unpaired *t*-test | Pretraining readings | | Post-training readings | |
|---|---|---|---|---|
| | Best right extension: best left extension | | Best right extension: best left extension | |
| | Group A (agility training) | Group B (control) | Group A (agility training) | Group B (control) |
| Mean | 0.98 | 0.91 | 1.10 | 0.87 |
| SD | 0.13 | 0.26 | 0.19 | 0.36 |
| Unpaired *t*-test | 0.82 | | 2.14 | |
| *P* value | 0.41 | | 0.04 | |
| Table value at 0.05 significance level with *d.f.* 28 | 2.05 | | 2.05 | |
| Result | Nonsignificant | | Significant | |

flexors can be reliably measured with a knee dynamometer in healthy middle-aged participants.

As the training was based on agility, Table 10 shows the difference in agility, which was measured through

**Table 9 Description of best right flexion : best left flexion**

| Unpaired t-test | Pretraining readings | | Post-training readings | |
|---|---|---|---|---|
| | Best right flexion: best left flexion | | Best right flexion: best left flexion | |
| | Group A (agility training) | Group B (control) | Group A (agility training) | Group B (control) |
| Mean | 0.91 | 0.89 | 1.06 | 0.81 |
| SD | 0.15 | 0.17 | 0.25 | 0.22 |
| Unpaired *t*-test | 0.44 | | 2.82 | |
| *P* value | 0.66 | | 0.00 | |
| Table value at 0.05 significance level with *d.f.* 28 | 2.05 | | 2.05 | |
| Result | Nonsignificant | | Significant | |

**Table 10 Comparison of agility (s) pretraining and post-training readings in experimental and control group (summary of Illinois agility test)**

| Illinois agility test | Time (s) | |
|---|---|---|
| | Control group ($n$=15) | Agility training group ($n$=15) |
| Pretraining (mean±SD) | 18.91±2.16 | 17.80±1.93 |
| Post-training (mean±SD) | 20.54±2.56 | 15.27±1.59 |
| Difference (pre–post) | −1.64 | 2.53 |
| $P$ | $P<0.0001$ | 0.002 |
| $t$ | 6.31 | 9.48 |
| $P$ (between groups) | $<0.0001$ | |
| $t$ (between groups) | 6.75 | |

Illinois agility test, and the results state that there is significant difference in the values.

## Conclusion

The results from our study are very encouraging and demonstrate 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 athletes can show significant improvement after 6 weeks of agility training.

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Nil.

### Conflicts of interest

There are no conflicts of interests.

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