2019 4(1) 1-7 Submission: 2019/05/10, Peer review: 2019/05/20, Accepted: 2019/05/25, Published: 2019/06/30

Kinesiology

Publication state: Japan
ISSN: 2435-0702

Publisher: J-INSTITUTE
Website: http://www.j-institute.jp

Corresponding author
E-mail: parkjs@kmu.ac.kr

Peer reviewer
E-mail: editor@j-institute.jp

http://dx.doi.org/10.22471/sport.2019.4.1.01

The Effect of Functional Training on the Physical Strength Factor of Elite TAEKWONDO Athletes

Park Ju-sik

Keimyung University, Daegu, Republic of Korea

Abstract

The purpose of this study was to investigate the effect of functional exercise program for 6 weeks(three times a week, 60 minutes / session) on eight elite Taekwondo players. The data were processed using SPSS/PC 18.0 program and the mean and standard deviation were calculated. The effect of functional exercise program was applied to the paired sample t-test.

Results, Body composition items were weight($p < .001$), BMI($p < .001$), In addition, functional exercise program effect was Back strength($P < .01$), sit-up($p < .01$), repeated jump($p < .01$) and side step($p < .01$) were found to be effective in basic physical fitness items. In addition, there was statistically significant difference($p < .05$) in all the measurement items as a result of Wingate test, an anaerobic exercise ability item before and after applying the functional exercise program. The maximal graded exercise test using treadmill showed a significant improvement($p < .05$) in maximum oxygen uptake(VO2max), exercise duration, and blood lactate concentration.

Results of this study, the functional exercise program used in this study is proposed as an appropriate program to improve the fitness factors required for Taekwondo training

[Keywords] ***Functional Exercise Program, Wingate Test, Maximum Oxygen Uptake, Blood Lactate Concentration, Body Mass Index***

1. Introduction

Taekwondo is our traditional martial art that has the purpose of self-defense for survival. However, the reason why it was developed into a sport that people from all over the world enjoy today is because it was selected for Seoul Olympic Games in 1988, and 31st Summer Olympics in Rio de Janeiro in Brazil in 2016. From a national point of view, Taekwondo has a high possibility of winning medals at the Olympic Games. In the same context, active research on the mechanistic analysis of movement, physical fitness training, physiological variables and psychological factors for the improvement of performance based on elite athletes has been conducted and progressed for the scientization of Taekwondo[1][2][3][4][5][6][7]. As can be easily seen from the various research data, most studies are focused on developing a technique-oriented approach to improving the performance of elite athletes and developing a training method to improve the professional fitness that affects performance[8][9]. However, many of Taekwondo majors are suffering from chronic body and leg injuries, which have been repeated many times during Taekwondo training. These injuries are a stumbling block to Taekwondo's continuous training[10]. Taekwondo training has a positive impact on physical development due to whole body exercise and integrated complex joint exercise. However, if proper functional exercise is not accompanied, there is a lot of movement that can induce leg injuries. Various kicking movements

move Taekwondo include ankle, knee and hip joint curve and extension as well as rotational movement, which can lead to serious damage if the connection of the exercise chains is improperly used chronically[11]. Therefore, this study is aimed at improving the internal stabilization muscle strength, which minimizes the risk of potential injury and the effective use of kinetic chain, which is emphasized in the functional exercise. Although this is not related directly to the improvement of the exercise performance to various types of Taekwondo practitioners, we want to develop an exercise program and apply it to elite Taekwondo players to determine its effect.

2. Method

2.1. Subjects

The purpose of this study was to investigate the change of body composition and physical fitness factors when a functional exercise program composed by the researchers is applied to 8 South America P nation players who participated in Muju WTF World Taekwondo Championships in 2017 for 6 weeks, 3 times a week, 1 hour a day. We fully explained the purpose and contents of this study to the subject, and all studies were conducted after preparing an agreement. The general characteristics of the subjects are shown in <Table 1>.

Table 1. Physical characteristics of study participants(n=8).

Items	Mean±SD
Age(years)	23.25±7.25
Height(cm)	174.21±9.22
Weight(kg)	61.76±6.79
BMI(kg/m2)	20.33±1.26

2.2. Measurement items and methods

1)Body composition

The body composition of the subjects was measured using an extensometer and InBody 3.0(Biospace, Korea) to calculate height, weight, and body mass index(BMI).

2)Basic physical examination

In order to confirm the change of basic physical strength before and after applying this exercise program, muscular strength(back strength), muscular endurance(sit-up), wakefulness(sargent jump), agility(side step), equilibrium(light, sound) were tested. All measurements were conducted twice and better values were used as the real values.

3)Maximal graded exercise test

Maximal graded exercise test was performed using a treadmill(Quinton 4,500) and a respiratory gas analyzer(QMC). Measurement protocol of Korean Institute of Sport Science(KSSI) was used to calculate oxygen uptake, respiratory exchange rate, anaerobic capacity and maximum heart rate. Maximal ability limit was limited to a time when the respiratory exchange rate was 1.15 or more, when exercise intensity was 17 or more, and when the maximum oxygen uptake did not increase although exercise intensity was increased. In addition, blood lactate concentrations were measured immediately after exercise and at 3, 7, and 10 minutes of recovery during maximal graded exercise test.

4)Anaerobic exercise test

Anaerobic exercise capacity was measured by Wingate test. Anaerobic power for 30 seconds was measured using a Bicycle ergometer(Monark 818E, Sweden). Considering the characteristics of this measurement, we conducted a preliminary training on measurement procedures to advance the measurement and reduce the will decrease and low power output phenomenon towards the end of the test. The following measurement items were calculated through measurement. Peak power was defined as the maximum power during maximum pedaling movement for 30 seconds and mean power was calculated by dividing the power during the maximum pedaling movement by 30 for 30 seconds. Fatigue index was calculated as[(maximum value - minimum value) / maximum value x 100] using the maximum value and minimum value during maximum pedaling for 30 seconds.

2.3. Functional exercise program

The purpose of this study was to develop an exercise program that can contribute to the improvement of motions and efficient motor learning. The exercise program was performed three times a week for one week and one hour daily. <Table 2> shows the composition of the functional exercise program.

Table 2. Functional exercise program.

Items	Move composition	Time
Mobilization	Movement enhancement of joints	About 10 minutes (1 min × 1set)
Movement	Multiple motion (3D) involving rotation of the trunk	About 10 minutes (1 min exercise × 5set)
Plyo	Plyometric exercise	About 10 minutes (1 min exercise × 5set) + 1 min challenge)
Cardio	Simple but intense exercise(HIIT)	About 10 minutes (1 min exercise × 5set + 1 min challenge)
Active balance	Active balance movement focused on hip movements	About 10 minutes (1 min exercise + 5set)

2.4. Data analysis

Data were processed using SPSS/PC 18.0 to calculate the mean and standard deviation, and a pair-sample t-test was conducted to examine the effect of the exercise program before and after the exercise.

3. Results

3.1. Changes in body composition and physical fitness

<Table 3> shows changes in body composition and basic physical strength after applying the functional exercise program. Body composition was significantly decreased in body weight($p<0.001$) and BMI($p<.001$). For basic physical strength, it was significantly increased in muscle strength in belly($p < .01$), sit-ups($p < .01$), repeated jumps($p < .01$), in-place long jumps($p < .01$), sargent jump($p < .001$), side step($p < .01$).

Table 3. Changes in body composition and basic physical strength.

Items	Pre	Post	t-value
Weight(kg)	61.76±6.79	59.71±6.88	10.637***
BMI(kg/㎡)	20.33±1.26	19.63±1.29	10.315***
Back strength(kg)	107.94±20.30	113.14±21.99	5.710**
Sit-ups(reps)	50.88±5.03	54.5±3.96	4.963**
Repeated jump(reps)	48.63±3.16	52.63±1.99	4.000**
Long jumpi(㎝)	210.45±24.53	220.91±21.04	3.998**
Sergent jump(㎝)	48.37±6.57	52.01±5.95	9.667***
Side step(reps)	48.25±3.33	50.88±4.45	4.930**
Standing with one foot with eyes closed (seconds)	41.02±3.33	50.6±40.23	5.629**
Responding to light (seconds)	0.293±0.044	0.295±0.032	0.248
Responding to sound (seconds)	0.283±0.04	0.285±0.038	0.930

Note: Value are mean±SD, **p<0.01, ***p<0.001, Mean±SD

3.2. Changes in anaerobic exercise capacity

The changes in anaerobic exercise capacity measured by Wingate test are shown in <Table 4>. Peak power($p < .001$), Mean Power($p < .05$), Total Power($p < .01$), Peak drop($p < .01$) After the exercise program, it was significantly improved.

Table 4. Changes in anaerobic exercise capacity.

Items	Pre	Post	t-value
PP (Watt)	495.06 ±131.45	521.45 ±128.33	7.079***
MP (Watt)	364.86 ±111.90	373.96 ±113.54	1.7782*
TP (Watt)	10575.50 ±3225.35	11578.0 ±3826.50	3.975**
PD (Watt)	55.12 ±6.12	58.87 ±7.26	5.495**

Note: Value are mean±SD, PP : Peak power, MP : Mean Power, TP : Total Power, FD : Peak drop, *p<0.05, **p<0.01, ***p<0.001

3.3. Changes in aerobic exercise capacity

The changes in aerobic exercise capacity after applying the functional exercise pro-

gram are shown in <Table 5>. Maximum oxygen intake($p < .001$), exercise duration($p < .001$), blood lactate peak($p < .05$) were significantly increased after applying functional exercise program. In addition, in order to check fatigue recovery, blood lactate peak was measured and it was significantly increased from recovery 3 min($p<.05$), 7 min($p<.01$), 10 min($p<.01$), as shown in <Table 6>.

Table 5. Changes in maximal exercise load test results.

Items	Pre	Post	t-value
VO2max (㎖/㎏/min)	50.10±5.54	51.00±5.24	7.079***
HRmax (time/min)	186.50±5.32	188.13±4.36	1.772
Time (sec)	815.13±118.27	944.0±124.09	0.829*
Lactate Peak (mM)	12.49±2.30	13.52±2.32	3.975**

Note: Value are mean±SD, *p<0.05, **p<0.01, ***p<0.001

Table 6. Changes in blood lactate concentration(mM).

Time	Pre	Post	t-value
Resting	2.90±1.15	2.45±0.63	0.987
After exercise	12.49±2.30	13.26±3.23	1.314
Recovery 3 min	12.10±2.62	13.50±2.58	3.068*
Recovery 7 min	10.78±2.60	13.10±2.74	3.884**
Recovery 10 min	9.57±2.22	11.88±2.45	4.846**

Note: Value are mean±SD, *p<0.05, **p<0.01

4. Discussion

This study is based on the previous studies of Akuthota, Ferreior, Moore, and Fredericson(2008), and analyzed the effect of functional exercise to optimize the ability of human body to exert force through action of core muscles[12]. The program was developed and applied to elite Taekwondo players for 6 weeks. In various previous studies, core stability training has been reported to significantly improve basic physical strength of athletes participating in sports such as track, volleyball, and soccer[13][14][15]. In addition, core and functional exercises have been reported to affect not only physical fitness but also health indicators related to growth of adolescent students[16][17][18].

Body composition and body mass index(BMI) decreased significantly in this study, and it was significantly increased in back strength, sit-up, in-place jump, sargent jump, repeating jump and side step. In the item of anaerobic exercise ability, there was a significant increase in both peak power, mean power, total power and peak drop. In addition, in the maximum exercise load test, which is a cardiopulmonary endurance test, it was able to confirm the effect of exercise program on maximal oxygen uptake, duration of exercise, and lactate concentration in recovery period.

As a result of applying the 6-week functional exercise program to national Taekwondo players, the increase in the power-related physical fitness items such as standing long jump and sargent jump items seemed to be influenced by the plyometric training included in the program. AS shown in the results of previous studies, the plyometric training has been used to improve the explosive power of the upper body, torso and lower body, and to increase the intrinsic sensory receptors in the body[19][20].

In the previous study, the 12-week periodic exercise using strength training and circuit training was performed to improve the performance of professional athletes[21]. As a result, a significantly improved results were obtained in half squat and Harvard step factors. This is similar to the content of the functional exercise program applied in this study. The five exercise tracks of MOBILIZATION, MOVEMENT, PLYO, CARDIO, ACTIVE BALANCE included in the contents of functional exercise program seemed to contribute to the improvement of internal stabilization muscle strength(core muscle) and efficient use of the kinetic chain in the functional exercise to improve the coordination with the lower extremity muscles and to improve the strength

and agility physical fitness factor. Byungju Park, Dongwook Ju(2011) suggested that Taekwondo players could have positive effects on the development of leg muscles and strength by applying various anaerobic training methods[22]. Daeryong Kim(2006) suggested the effect of combined training of abdominal muscles and lower extremities as a method to strengthen leg muscles and stability of Taekwondo athletes[11]. The functional exercise program used in this study also includes both the core muscles and lower extremity muscles, and it is possible to say that it includes all the exercise programs performed in the previous study.

Lactate concentration in blood is an index representing the ability to use aerobic and anaerobic energy. When the blood lactate concentration reaches 4 mmol/L, it is explained as Anaerobic Threshold. As a result of confirming the changes of lactate concentration in blood before and after applying the functional exercise program, it was significantly increased from lactate maximum level and recovery 3 min($p < .05$), 7 min($p < .01$), and 10 min($p < .01$). Harris, Sahlin, Hultman(1977) reported that the concentration of lactate in blood during stabilization was 0.56 ~ 2 mmol/L[23]. As the concentrations of lactate in blood before and after the exercise program of this study was included in this range, it can be confirmed that the subjects were in the same condition during the measurement of two periods. In addition, the results of previous studies showed that players with good physical abilities had the ability to last a longer period of exercise with high lactate content, and it is reported that this can be a criterion of fitness level[24][25]. Related to this, there was a significant increase in maximal oxygen uptake($p<.001$), exercise duration($p<.05$), and peak lactate($p<.01$) in this study. It is considered that it had a positive effect on the maximum athletic performance improvement of the elite Taekwondo athletes.

4. Conclusion

The purpose of this study was to investigate the possibility of minimizing the risk of potential injury by improving exercise performance through application of newly developed functional exercise program to elite Taekwondo athletes. The results of the study showed that functional exercise program had a positive effect on body composition, basic physical strength and professional physical fitness. In addition, it was found that it significantly contributed to the improvement of anaerobic exercise capacity and cardiopulmonary capacity.

Therefore, it is thought that the functional exercise program used in this study can be used to improve physical imbalance and physical fitness of Taekwondo athletes as well as Taekwondo practitioners. However, in order to generalize the results of this study, it is necessary to analyze the subjects according to age, gender, and type of training in future studies.

5. References

5.1. Journal articles

[1] Koh YJ & Lee MG & Kong SA. Comparison of Body Composition, Physical Fitness, and isokinetic Leg Strength according to Competition Level in Collegiate and High School Taekwondo Players. *Exercise Science*, 16(4), 411-420 (2007).

[2] Kim GS. The Body Composition and Basic Physical Fitness Discriminant Analysis of Taekwondo Player. *The Journal of Korean Alliance of Martial Arts*, 6(1), 49-58 (2004).

[3] Park IR & Jun TW & Park KS & Ryoo BK & Choi JH. A Study on the Change of Heart Rate, Blood Lactate, Blood Pressure and MVO_2 in Taekwondo Athletes during Taekwondo Competition. *The Korean Journal of Physical Education*, 41(5), 613-621 (2002).

[4] Jeong KH & Kim HS. The Performance Forming Factors of the National Taekwondo Team Athletes. *Korean Journal of Physical Education*, 43(5), 475-484 (2004).

[5] Kim BJ. Techniques for Cross-cultural Translation and Validation of Questionnaires. *Korean Journal of Sport Psychology*, 14(1), 13-26 (2003).

[6] Lee ES. A Study on the Determinate Factor of Performance in Taekwondo Competitor. *Journal of Korean Society for the Study of Physical Education*, 8(3), 207-216 (2003).
[8] Lee JG & Ko BG & Kim YS & Park DH & Chung DS & Bang DD & Bang SS & Chun MB. Effects of Short-term and Long-term`s CGM-M Treatment on Elite Athlete`s Central Fatigue and Metabolic Factors. *Korean Journal of Sport Science*, 14(3), 48-61 (2003).
[12] Akuthota V & Ferreiro A & Moore T & Fredericson M. Core Stability Exercise Principles. *Current Sports Medicine Reports*, 7(1), 39-44 (2008).
[13] Yang SW. The Effect of Core Training on Isokinetic Muscle Power of Knee Joint and Lumbar Joint in Short-distance Athlete. *Journal of Coaching Development*, 16(2), 81-87 (2014).
[14] Sharma A & Geovinson SG & Singh Sandhu J. Effect of a Nine-week Core Strengthening Exercise Program on Vertical Jump Performances and Static Balance in Volleyball Players with Trunk Instability. *Journal of Sports Medicine & Physical Fitness*, 52(6), 606-615 (2012).
[15] Kim NJ. The Effects of Core Muscle Strengthening Training on Isokinetic Leg Muscular Strength and Balance Control Ability of Female High School Soccer Players. *The Korean Journal of Physical Education*, 53(4), 495-504 (2014).
[16] Song HS & Kim KJ & Park JC & Woo SS & Kim JY & So WY & Kim LN. Effect of 16-week Functional Movement Improvement Training Program for Injury Prevention on Functional Movement Screen(FMSTM) Test Score in High-school Baseball Players. *Korean Journal of Sport Science*, 26(2), 391-402 (2015).
[17] Leetun DT & Ireland ML & Willson JD & Ballantyne BT & Davis IM. Core Stability Measures as Risk Factors for Lower Extremity Injury in Athletes. *Medicine & Science in Sport & Exercise*, 36(6), 926-934 (2004).
[18] Peate WF & Bates G & Lunda K & Francis S & Bellamy K. Core Strength: A New Model for Injury Prediction and Prevention. *Journal of Occupational Medicine & Toxicology*, 2(3), 1-9 (2007).
[19] Gregory D & Myer & Keivin R & Ford & Joseph P & Palumbo & Timothy E & Hewett. Neuromuscular Training Improves Performance and Lower-extremity Biomechanics in Female Athletes. *Journal of Strength & Conditioning Research*, 19(1), 51-60 (2005).
[20] Imai A & Kaneoka K & Okubo Y & Shiraki H. Effects of Two Types of Trunk Exercises on Balance and Athletic Performance in Youth Soccer Players. *International Journal of Sports Physical Therapy*, 9(1), 47-57 (2014).
[21] Yoon JW. The Circuit Weight Training Program Development for a Taekwondo Condition Power Improvement. *Korean Journal of Sports Science*, 17(4), 1323-1332 (2008).
[22] Park BJ & Joo DW. The Effects of Difference of Training Method of Taekwondo Athlete on Lower-limb Muscle Functional. *The Journal of Korean Alliance of Martial Arts*, 13(1), 171-185 (2011).
[23] Harris RC & Sahlin K & Hultman E. Phosphagan and Lactate Contents of M Quadticeps Femoris of Man after Exercise. *Journal of Applied Physiology*, 43(5), 852-857 (1977).
[24] Ekblom B & Astrand PO & Saltin B & Stenberg J & Wallström B. Effect of Training on Circulatory Response to Exercise. *Journal of Applied Physiology*, 24(4), 518-28 (1968).

5.2. Thesis degree

[7] Lim SJ. Development of Pattern and Model for Taekwondo Competitional Sparring Techniques. Sungkyunkwan University, Doctoral Thesis (2005).
[10] Jin JS. A Study on Physical Injury Prevention and First-aid Satisfaction of Taekwondo Athletes. Korea National University, Master's Thesis (2008).
[11] Kim DR. A Study on the Effective Rehabilitation Training Method for Taekwondo Competitors after Surgery of the ACL. Yongin University, Master's Thesis (2006).

5.3. Books

[25] Jung ST. Physiological Foundation of Physical Education. Donghwa Cultural History (1978).

5.4. Additional references

[9] Song HS & Park DH & Kim HS. Development and Application of Strength Training Program for Elite Swimmers by Training Stage.

Research Report of the Korean Journal of Sport Science (2006).

Author
Park Ju-sik / Keimyung University Professor
B.A. Keimyung University
M.A. Keimyung University
Ph.D. Keimyung University

Research Field
- Anti-inflammatory Effect of Cynanchone a Isolated from Cynanchum Wilfordii in RAW 264.7 Macrophages, International Journal of Sports, 2(1) (2017).
- Effects of Long-term Endurance Exercise and Salvia Miltiorrhiza Vinegar on Body Composition and Insulin Resistance in High Fat Diet-induced Obese Rats, Korean Journal of Food Preservation, 24(5) (2017).
- The Effects of AMPK Activation Induced by Endurance Exercise on Glucose Uptake Via AKT/AS160, Korean Journal of Sport Studies, 57(6) (2018).
- An Estimation Model for Anaerobic Power of Taekwondo Athletes Based on Field Tests, Journal of Martial Arts Anthropology, 19(1) (2019).

Major Career
- 2005~2014. Gyeongju University, Professor
- 2015~present. Keimyung University, Professor