Effects of Whole Body Vibration on Power Performance and Lactate Concentration in Speed Kicking of Taekwondo

Abstract

This study attempted to investigate whole body vibration (WBV) that has been utilized as a new form of muscular training method by applying it into Taekwondo training and to examine its effects on power performance and lactate concentration during the speed kicking. For the same participants (testees), 1-minute speed kicking per each round during the 3-round period and 1-minute static rest were given in the first experiment, while a 5-minute whole body vibration was conducted before starting the 1st round and whole body vibration was conducted during the rest period (in-between rounds) in the second experiment. In order to measure power performance, the study measured the number of each round's speed kicking and serum LDH activation level right after finishing up each round, and to measure the level of fatigue recovery, it measured the lactate concentration according to the passage of recovery time; then, they were statistically analyzed and the following results were obtained. First, it has been shown that the performance of whole body vibration increased the number of repetition in speed kicking in Taekwondo and serum LDH activation level that eventually improved power performance. Second, it has been demonstrated that whole body vibration increased an ability to recover muscular fatigue by removing the lactate in the blood during the recovering period. From the said results, it has been firmed believed that it would be an effective training program to apply whole body vibration into Taekwondo training that could enhance the performance of athletes by improving their ability to conduct power performance and to recover muscular fatigue that could be a crucial factor.

Key words: WBV (whole body vibration), Taekwondo, training, power performance, muscular fatigue
I. Introduction

Taekwondo competition consists of 2 minutes and 3 rounds with 1 minute rest in between each round, and it is a high impact intermittent form of exercise composed of fierce movements of kicking, punching, and defending; and it is a competitive game that requires sophisticated anaerobic physical strength as well as basic aerobic physical strength. In Taekwondo match, all-out time is given externally by match regulations, while exercise intensity and frequency vary in accordance with the internal elements of match, that is to say, movement of kicking techniques and frequency of attack and counterattack corresponding to opposite competitor’s tactical types (Lee Seonjang, Kim Hakryeol and Jung Gukhyeon, 2001). Therefore, in order to improve the performance in Taekwondo, it is essential to have physical strength that can attack the moving opposite competitor or defend his/her attack and dominate the 3-round match with high concentration (Lee Seungguk, 1996).

There have been many studies on the elements of physical strength necessary to Taekwondo match, and Lee Seonjang et al. (2001) claimed that it would be a crucial factor determining the performance to have an ability to improve tolerance to accumulated fatigue substances or remove them swiftly while mobilizing aerobic and anaerobic metabolic capability. Meanwhile, Lee Seungguk (1996) emphasized that it would be necessary to have agility and stamina to perform an offensive match. In addition, Lee Eunsong (2003) mentioned that one had to improve muscular strength, agility, and shrewdness so as to enhance the performance in Taekwondo and Jung Gukhyeon and Kim Hyeonsik (2004) said that an offensive style all the time during the match would be advantageous to the match and it would be necessary to have strong physical strength such as muscular endurance, agility and shrewdness to lead the match.

When summarizing the aforementioned research results, it is necessary to have strong physical strength that can perform offense and defense continuously all the time during the match. Meanwhile, when considering that Taekwondo match is an intermittent high-intensity exercise in terms of physical factor, it is thought to need muscular strength factors such as muscular strength, muscular endurance and agility and anaerobic endurance, rapid ability to recover fatigue and agility, etc.

Whole body vibration (WBV) has been introduced newly in the field of muscular function training in late 1990s and it has been widely applied to various fields such as professional sports teams, fitness centers, rehabilitation clinics in the USA and Japan as well as in European countries. Whole body vibration is a method that adds new stimulations by artificially controlling gravitational load and contracting muscles rapidly and strongly (Bosco, 1992). In fact, the method of improving the explosive power of muscles by controlling gravitational load as in whole body vibration has been conducted by hanging additional weight on the body and jumping (Bosco et al., 1984; Bosco, 1985). However, such training methods do not have quantitative standards and can be too sensational and harmful to human body, and they may be excessive training load to young athletes that can cause side-effects by them.

Therefore, various mechanical equipments have been recently developed (Galileo2000®, Power-Plate®, Fitvibe®, Turbo-trainer®, etc.) that can improve muscular functions by adding new stimulus to muscles by means of controlling gravitation artificially and quantitatively while not being burdensome to human body and various research results with regards to whole body vibration using these equipments have been published.
Cardinale (2002) conducted a 10-day whole body vibration test for 62 persons who were participating in a regular exercise program and studied its effects on jump power by using 5c of continuous jumping (5s CJ) and found out that the average jump height improved by 11.9% in the experimental group and the highest jump height and the average jump power during the highest jump height increased significantly. Meanwhile, Trovinen et al. (2002) performed a 4-month whole body vibration test 3-5 times a week for 56 healthy men and women and the vertical jumping performance increased by 10.2% in two months and by 8.5% in four months in the experimental group and the flexion muscle strength of leg muscle increased by 3.7% in two months and by 2.5% in four months. In addition, Delecluse, Roelants and Verschueren (2003) divided 67 women who have not participated in specific physical activities into the resistance exercise group, whole body vibration group, whole body vibration-placebo group, and control group and conducted a 12-week-long program for them; as a result, static and dynamic muscular strength increased significantly in resistance exercise group and whole body vibration group and its increase rate was larger in whole body vibration group than in resistance exercise group, and significant aspects were shown only in whole body vibration in the comparison of jump power using a CMJ (counter movement jump), but there were no changes in the size of muscle fiber.

Considering the results of these researches, it has been shown that the performance of whole body vibration could improve the functions of nervous system without changing the size of muscle fiber. Furthermore, it has been reported that whole body vibration had positive effects on the change in hormone secretion (Kerschan-Schindl et al., 2001), increase in the intake of the amount of maximum oxygen (Bosco, etc., 2000), increase in bone density (Verschueren, 2004) and pacification of pain (Rittweger, Just, Kautsch, Reeg & Felsenberg, 2002).

The head coach of Korean national team in 2002 World Cup, Guus Hidink, first introduced the whole body vibration equipments into Korea as part of a power improvement program (Im Yongtaek, 2005) and since then, they have been gradually used in obesity clinics, rehabilitation and pain clinics. However, they are not widely used in professional sports field and there is lack of information or recognition on them.

As a unique self-defense that has contributed to the expansion of our national power and the cultivation of national prestige in various aspects as well as in sports field, Taekwondo has to improve its spiritual and performance aspects continuously; otherwise, as in Judo of Japan, other countries may intimidate the status of suzerain. Therefore, in order for our country to maintain the suzerain status of Taekwondo continuously and have good outcome in international competitions, there should be improvements in physical strength considering the characteristics of Taekwondo competition through endless technical development, scientific and systematic training. In this aspect, even if there should be more researches on accurate electric generation or effects; however, it will be a starting point of the study that can find a new training method to combine whole body vibration (that has been proven that it would enhance the overall muscular functions in the preceding researches) with the Taekwondo training that needs strong muscular functions.

In this regard, the purpose of this study is to suggest scientific and systematic data for the effects of whole body vibration on the improvement of muscular functions and to contribute to the science of Taekwondo and improvement of competition performance, by closely examining the effects of a new form of training method, whole body vibration, on the enhancement of power performance ability and
fatigue recovery ability that can be crucial factors in Taekwondo competitions, by means of applying whole body vibration into Taekwondo match.

II. Study Method

1. Subject of study
The subject of study included 10 students who had voluntary intention to participate among the athletes on the playing list with more than 2nd grade black belt from the department of Taekwondo at N University located in Cheonan City, Chungcheongnam-do and their physical characteristics are shown in <Table 1>.

<Table 1> Physical characteristics of the subject of study

<table>
<thead>
<tr>
<th>Group</th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>Body fat percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td>22.31 ±0.93</td>
<td>176.53 ±3.71</td>
<td>68.48 ±4.01</td>
<td>18.52 ±3.42</td>
</tr>
</tbody>
</table>

2. Equipments Used
The equipments used in this study are shown as in <Table 2>.

<Table 2> Study equipments

<table>
<thead>
<tr>
<th>Usage</th>
<th>Name of equipments</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole body vibrator</td>
<td>Turbo-trainer</td>
<td>TSKOREA, Co., Ltd.(KOR)</td>
</tr>
<tr>
<td>Lactate analyzer</td>
<td>YSH500</td>
<td>YSI Co. (USA)</td>
</tr>
<tr>
<td>EMG tester</td>
<td>WEMG-8</td>
<td>LAXRHA Co., Ltd.(KOR)</td>
</tr>
</tbody>
</table>

3. Study method and procedures
This study was conducted according to the following methods and procedures.

1) Basic inspection and equipment adaptation exercise: Height, weight and body fat percentage were measured through body composition analysis for the subject of study and a 10-minute adaptation exercise was conducted the day before the test to let them be adjusted to unfamiliar whole body vibration.

2) 1st experiment: The 1st experiment was conducted according to the procedures shown in <Figure 1> below.

   <Figure 1> 1st experimental procedures

   1) Measurement in the stable period: All the subject of study performed a warming up with a five-minute light stretching before entering the experiment and a preliminary inspection was conducted after the warming up. 10ml of blood from 주정중피 정맥 (antenecubital vein) was collected for measuring the activation of serum LDH.

   (2) Speed kicking: For speed kicking, the participants were asked to use both legs to do kicking as many times as possible for the target located in the height of waist for 60 seconds and their assistants gave a verbal encouragement to them to have the maximum results. The reason for setting up the time of
speed kicking as 60 seconds was that it would become an aerobic exercise in case that it exceeded 60 seconds in terms of the process of energy metabolism so that it would be a method for measuring stamina (endurance) rather than the muscular power. Meanwhile, the test was conducted for 3 rounds, which were actual number of rounds in Taekwondo match, so as to set up a similar environment to actual match.

(3) Interim measurement: The interim measurement was conducted during the rest period and it was a static rest, in which participants took a rest by sitting on a chair. Before entering the next round after closing the rest period, a blood collection was made to measure lactate concentration using a finger-tip. The rest period lasted for a minute to set up the similar environment to actual match.

(4) Measurement of recovering period: The recovering period measurement was conducted 3 minutes after finishing up the 3 round match and a blood collection was made in the same way as the measurement in the stable period and interim measurement.

3) 2nd experiment: The 2nd experiment was performed for the same participants and procedures as the 1st experiment (Figure 2).

4. Measurement items and methods
The study measured an electromyogram (EMG) for each part according to each number of vibrations (Hz/sec) of whole body vibration through a preliminary experiment, and it measured the number of speed kicking, the activation of serum LDH and lactate concentration among each measurement time by each round after conducting the 1st and 2nd experiments.

1) Number of speed kicking by each round
The study measured the number of speed kicking by each round through the 1st and 2nd experiments and two persons counted it at the same time so as to avoid the errors.

2) Measurement of serum LDH activation
Serum LDH activation can be utilized as an index of measuring the exercise intensity operated in the unit time (Tanada et al., 1993). Therefore, this study measured the serum LDH activation to estimate the power performance ability by measuring the strength of exercise performed by the participants in the experiment for a minute. The measurement was conducted four times in the 1st experiment: in the stable period, after finishing up the 1st, 2nd and 3rd round, and it was conducted five times in the 2nd experiment: in the stable period, after finishing up whole body vibration, 1st, 2nd and 3rd round. Especially, in order to prevent the stress of the participants that could be occurred by repetitive blood collection, a catheter was attached to their 주민등록증??? before conducting the test. Collected blood was put in a BD vacutainer and was coagulated for 30 minutes in room temperature and was centrifuged for 10 minutes at 3,000 rpm. Centrifuged blood was analyzed by the professional blood analysis company, Neodin Co., Ltd..

3) Measurement of lactate concentration in the blood
The measurement of lactate concentration in the
blood was conducted five times in the 1st and 2nd experiments: recovering period, 3 minutes, 5 minutes, 7 minutes, 10 minutes and 15 minutes. The blood collected by a finger-tip was analyzed immediately by the lactate analyzer, YSI 1500.

4) Performance of whole body vibration
Whole body vibration has not a generally applied protocol and especially, its effect can be varied according to the electric generation that causes the vibration of its equipment; in this regard, this study attempted to establish the number of vibration for whole body vibration that would affect the muscular group of human body to a great extent through the preliminary experiments using an electromyogram measurement and the results of EMG analysis could be found in the preceding thesis of the researcher of this study (Im Yongtaek, 2005). Based on the preliminary experiments, this study conducted 24Hz(3min)-12Hz(2min) before the 1st round performance and 8Hz(1min) during the rest period.

5. Date treatment
The data collected through the said experimental procedures were treated by using a SPSS statistics program (Ver 12.0) as in the following.

1) The mean and standard deviation of all measured items were obtained.

2) A 2(group)*3(time) repeated measures ANOVA was conducted to examine closely the effects of whole body vibration on the number of speed kicking by each round.

3) A 2(group)*5(time) repeated measures ANOVA was conducted to examine closely the effects of whole body vibration on the level of serum LDH after the rest period and closing each round.

4) A 2(group)*5(time) repeated measures ANOVA was conducted to examine closely the effects of lactate concentration in the blood.

5) The significance level (α) of hypothesis testing was set as .05.

III. Study results
This study attempted to grope for the method that could be helpful to the improvement of performance of Taekwondo athletes by applying whole body vibration that has been introduced as a new training method for the improvement of muscular functions. In order to closely examine the effects of muscular power performance and muscular fatigue recovery that could function as a factor that determined the performance in Taekwondo match, it analyzed the effects of whole body vibration on the number of speed kicking, serum LDH activation and lactate concentration in the blood during the recovering period, by using the performance of 3-round speed kicking and each rest period. Then, the following results have been obtained.

1. Change in the number of speed kicking
In order to closely examine the effects of whole body vibration on the power performance of Taekwondo athletes, this study investigated the change in the number of speed kicking by whole body vibration performed before each round as in <Table 4>. Repeated measures ANOVA for the number of speed kicking by each group had significant differences [F(2, 36)=29.43, p<0.05] according to each measured time and it was not significant statistically between groups, but 3-4 times increased on the average when comparing it by each round.
Meanwhile, it has been found that reciprocal action for group and measured time was not significant.

2. Change in Serum LDH activation
In order to closely examine the effects of whole body vibration on the power performance of Taekwondo athletes, this study investigated the change in serum LDH activation as in <Table 5> after finishing up each round by whole body vibration conducted before entering each round. The results of repeated measures ANOVA between the entire group and time for the change in serum LDH activation were as in <Table 6>.

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was shown as in <Table 7> so as to closely examine the effects of the performance of whole body vibration on fatigue recovery of Taekwondo athletes. The results of repeated measures ANOVA between the entire group and time for the change in lactate concentration during the recovering period were as in <Table 8>.

<Table 8> Change in lactate concentration in the blood during the recovering period according to the performance of whole body vibration

<table>
<thead>
<tr>
<th>Group</th>
<th>Rest Period</th>
<th>3 min</th>
<th>5 min</th>
<th>7 min</th>
<th>10 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip</td>
<td>10.54</td>
<td>10.14</td>
<td>9.87</td>
<td>9.57</td>
<td>8.73</td>
</tr>
<tr>
<td>(N=10)</td>
<td>±2.18</td>
<td>±1.74</td>
<td>±2.00</td>
<td>±1.94</td>
<td>±1.90</td>
</tr>
<tr>
<td>Press</td>
<td>10.99</td>
<td>10.01</td>
<td>8.89</td>
<td>8.55</td>
<td>7.45</td>
</tr>
<tr>
<td>(N=10)</td>
<td>±1.36</td>
<td>±1.45</td>
<td>±1.79</td>
<td>±1.78</td>
<td>±1.77</td>
</tr>
</tbody>
</table>

As shown in <Table 8>, repeated measures ANOVA for lactate concentration in the blood during the recovering period by each group showed significant differences \[ F(4, 72)=42.60, \, p<0.05 \] according to each measured time; however, it was not significant statistically between groups, but it has been found that it reduced approximately by 1mmol/1 according to the passage of time. Meanwhile, it has been shown that the reciprocal action for group and measured time was significant \[ F(4, 72)=5.41, \, p<0.05 \].

<Table 9> Results of repeated measures ANOVA for the change in lactate concentration in the blood during the recovering period according to the performance of whole body vibration

By IV. Discussion

It is the most important way to determine victory and defeat in sports to demonstrate one's inborn potential talents through physical training, but most of sports athletes, instructors or sports scientists attempt to find out new methods endlessly to have better performance than opposite athletes. These methods could be divided into internal and external parts of training: the development of new techniques and more efficient training methods for the former and that of performance supplement such as materials called Ergogenic Aids, techniques, devices, etc.

Whole body vibration that has been newly developed and utilized in this aspect has been introduced in the field of muscular function training in the late 1990s and it has been widely used by many sports teams in the USA and Japan as well as in European countries and there have been various studies on the effects of whole body vibration on muscular function improvement, circulatory and skeletal system.

When looking at the effects of whole body vibration on muscular function improvement, Bosco et al. (1999) claimed that the one-time treatment of whole body vibration would affect the improvement of the power and contraction speed of leg muscles; meanwhile, Issurin, Liebermann and Tenenbaum (1994) mentioned that the group that performed muscular strength training including whole body vibration demonstrated significantly higher improvement in muscular strength compared to the group that performed muscular strength training only. In addition, Bosco et al. (1998) described that the performance of whole body vibration improved a
vertical jumping ability significantly.

With regards to the researches on the effects of circulatory system, Kerschan-Schindl et al. (2001) increased the blood velocity and decreased blood resistance index significantly, and Rittweger, Schiessl and Felsenberg (2001) mentioned that maximal oxygen uptake during whole body vibration increased twice than during the stable period.

In addition, there was a report by Bosco et al. (2000) that hormone reaction after conducting whole body vibration was identical to that after doing a weight training; furthermore, there was a research by Sabine et al. (2004) that bone density of women after menopause increased through 6-month whole body vibration.

By applying such whole body vibration, this study examined its effects on the improvement of an ability to develop muscular power performance and to recover muscular fatigue. As factors that measured muscular power performance, the number of speed kicking by each round and serum LDH activation were measured and lactate concentration during the recovering period was measured for the factor of an ability to recover muscular fatigue.

In terms of the number of speed kicking, there were no significant differences before and after the performance of whole body vibration. However, it has been found that there were 3-4 times of increases on the average by each round, and when considering that the participants in the experiments were the athletes on the playing list who had almost physical limitations on their speed kicking ability due to continuous high-strength training, it would be a significant change. It would be similar to Bosco et al. (1999b)’s research results that one-time treatment of whole body vibration affected the improvement of the power and contraction speed of leg muscles, and it would be a very meaningful result to Taekwondo athletes who had to attack opposite athletes’ weaknesses accurately with spontaneous movement using their legs.

Serum LDH activation increased by exercises and it could be utilized not only as an index indicating the damage degree of body and muscular cells, but also as enzyme that could make the equilibrium of catabolism and assimilation of sugar content and indicate the energy metabolism; therefore, its exercise physiological utilization would be great (Yoon Jonggwan). The LDH showed that it increased to a great extent due to the short-term and long-term severe exercises (Collinson et al., 1995), and it increased in proportion to all-out time in the same exercise strength and to exercise strength in the same exercise time (Tanada et al., 1993).

As a result of conducting whole body vibration before doing speed kicking, this study found that it demonstrated the significant aspects of serum LDH activation; meanwhile, when considering that it would increase in proportion to exercise strength in case that exercise time was the same, it indicated that Taekwondo athletes performed higher strength exercises through whole body vibration and it signified that it would be related to the improvement of muscular power that functioned as a crucial factor in the main performance of Taekwondo match.

In Taekwondo match, athletes always face against opposite athletes and conduct spontaneous and severe movements; for this reason, substance causing fatigue in working muscles, lactic acid, will be accumulated relatively in a brief space of time and the fatigue of the entire or part of body will take place. The match is conducted intensely for 2 minutes and 3 rounds and there is only one minute rest in between each round and athletes have to do several matches a day; therefore, they absolutely need an ability to have a resistance to lactate concentration that they can
overcome and to remove lactate rapidly. In case that athletes’ resistance to lactate improves, they can increase the generation of lactate in the body during the exercise and they are likely to feel less fatigue owing to the increased lactate. In order to achieve the said result, it is necessary to have a training program that can improve the lactate concentration in the body through almost the maximum intensity (Korea Institute of Sport Science, 1999).

As a result of conducting whole body vibration before doing speed kicking, this study found that there were no significant differences between groups in the lactate concentration during the recovering period, but the maximum value of average lactate concentration increased approximately 0.5mmol/ litre and the speed of removing lactate increased during the recovering period. The reason for the increase in the highest value of lactate concentration was that the participants performed higher intensity exercises through whole body vibration; meanwhile, the increase in the speed of removing lactate during the recovering period derived from the fact that whole body vibration increased blood flow twice and decreased blood resistance index and improved blood circulation (Kerschan-Schindl et al., 2001). It would be very meaningful to Taekwondo athletes because fatigue recovery through removing the lactate in the body rapidly during and after the match would be a crucial factor.

As a national sport in Korea, Taekwondo is an important competitive game in terms of maintaining the status of one of the strongest countries in sports. However, Korean Taekwondo has been recently challenged heavily by many countries, and actually its performance outcome in international Taekwondo competitions has become worse. In order to overcome the challenges and maintain our suzerain status, it is essential to develop new training methods. Even if the concept of whole body vibration has been established not more than 10 years, many sports teams have used it as part of improving muscular training. Nevertheless, its use has been not enough in Korea. Therefore, this study attempted to figure out a method of improving performance by utilizing whole body vibration in Taekwondo and its results could be summarized as in the following:

First, it has been found that whole body vibration increased the number of repetition in speed kicking and serum LDH activation and eventually improved power performance. Second, it has been demonstrated that whole body vibration increased an ability to recover muscular fatigue by removing the lactate in the blood during the recovering period.

From the said results, it has been firmly believed that it would be an effective training program to apply whole body vibration into Taekwondo training that could enhance the performance of athletes by improving their ability to conduct power performance and to recover muscular fatigue that could be a crucial factor.