Original Article

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Training effects of Dahn Taekwondo's Spondylitis Improvement Program on ankylosing spondylitis: a case study

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Abstract

Introduction: This case study applied the Dahn Taekwondo Spondylitis Improvement Program (DTSIP) to a 30-year-old male with ankylosing spondylitis five times a week for 28 weeks. *Materials and Methods:* A 32-year-old male with ankylosing spondylitis underwent the Dahn Taekwondo Spondylitis Improvement Program (DTSIP), an amalgamated program of standard Western medicine practices and complementary and alternative medicine (CAM) exercises based in the oriental medicine practices of yoga and taekwondo. The subject performed the DTSIP 5 times a week for 90 minutes for 28 weeks. *Results:* First, blood C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and platelet levels decreased by approximately 29-71%. Second, blood leukocyte counts decreased by about 11%. Third, as a result of Bath Ankylosing Spondylitis Metrology Index (BASMI) measurement, tragus to wall (TWD), lumbar side flexion (LSF), LF (lumbar flexion), and intermalleolar distance (IMD) were improved substantially. The students' cervical vertebrae and thoracic and lumbar vertebrae ranges of motion were additionally improved. The range of motion of the shoulder and hip joint improved. *Conclusions:* Therefore, the DTSIP seems to have a positive effect on the inflammation, immune functions, and spine and joint range of motion in the subject of this case study. Future studies are required with a wider sample population to validate these results.

Keywords: complementary and alternative medicine (CAM), ankylosing spondylitis, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), Bath Ankylosing Spondylitis Metrology Index (BASMI), *Ki*

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INTRODUCTION

The development of today's dependency on scientific advancements has increased the physical and mental dissonance due to a decrease in physical activity and overeating [1]. Patients with lifestyle-related diseases are on the rise every year. Lee [2] reported that the diseases caused by abnormalities of immune function (e.g., autoimmune diseases) and allergies (e.g., ulcerative colitis and Crohn's disease) are increasing continuously. An autoimmune disease is a disease caused when a body's immune system attacks its organs. Systemic lupus erythematosus, allergic rhinitis, rheumatoid arthritis, and ankylosing spondylitis are such diseases. The cause of autoimmune disease in both Western medicine and Oriental medicine practices has not been clearly elucidated, so a universal therapy method has yet to be developed. In particular, ankylosing spondylitis requires constant symptom management, because the disease may worsen without proper care of its symptoms.

Ankylosing spondylitis is an inflammatory disease predominant in young males in their 20s and 30s that is caused by autoimmunity. There are about 1 to 2 cases per 1,000 people of ankylosing spondylitis, and its world prevalence rate ranges from 0.1 to 1.4% [3]. It is characterized by the immune system attacking the ligaments that connect the vertebrae, resulting in inflammation and tissue fusing the spine. Symptoms may appear anywhere the autoantibody is attacked, including the spine, knee, heel, and ribs as well as in the eyes, heart, kidney, lung, prostate, and colon. Furthermore, ankylosing spondylitis may cause the ribs to fuse to the spine or sternum, which may hamper deep breathing. This abnormal fusion of bones may impair daily functions. Symptoms include pain and stiffness in the lower back and pelvic region. As such, ankylosing spondylitis is a serious disease that causes various pathological symptoms [4].

Western and Oriental medicines view the causes of spondyloarthritis diseases like ankylosing spondylitis from different perspectives. Western medicine presumes autoimmune diseases are caused by combined genetic factors, irregular lifestyle, and various environmental factors, such as mental stress. In Oriental medicine, it is believed that the eosinophils is caused by a circulatory disorder strikes the various tissues in our body and causes inflammation. Because of these different viewpoints on the cause of spondyloarthritis, Western medicine and Oriental medicine have different therapeutic approaches.

Western medicine mainly treats ankylosing spondylitis with surgery, medication, and exercise therapy. Amongst them, medication is mainly used to control the inflammation while reducing pain and stiffness. However, it is reported that continuous drug therapy is accompanied by various complications including gastrointestinal disorders [5-7]. In Oriental medication, nutritional, and physical therapies are performed [4]. Previous studies have reported that regular joint mobility enhancement and strength exercise are more effective than drug and physical therapies in ankylosing spondylitis therapy [8-10]. Analay et al. [11] reported an increase in physical function when an intensive exercise program was applied for 6 weeks to an ankylosing spondylitis patient. Russell, Unsworth, and Haslock [12] reported that 2 to 6 months of physical therapy, including exercise therapy, was effective in improving ankylosing spondylitis patients' cervical flexion, extension, and rotation. Kraag et al. [13] reported that spasticity increased after 24 months of home exercise in 24 patients with ankylosing spondylitis. Zão and Cantista [14] analyzed 35 studies involving a total of 2,515 patients with ankylosing spondylitis and reported that the effects of both ground and underwater exercises were positive. Pécourneau et al. [15] conducted a meta-analysis of 26 randomized controlled trials of patients with ankylosing spondylitis and reported that exercise programs had a potential to improve disease activity and physical function.

In studies conducted within the Republic of Korea (ROK), it was reported that applying home exercise programs as recommended by the American Society of Spondylitis [16], tai chi [17], and special exercise therapies [18] improved joint mobility, daily function, and pain levels in subjects with ankylosing spondylitis. As noted above, the existing ankylosing spondylitis exercise studies have focused on vertebral flexibility, pain, and depression. Korean exercise therapy evaluation tools incorporated the Bath Ankylosing Spondylitis Functional Index (BASFI), Bath Ankylosing Spondylitis Disease Activity Index (BASANI), and Visual Analogue Scale (VAS) questionnaires. Outside of Korea, spinal movement range measurements, such as the Bath Ankylosing Spondylitis Metrology Index (BASMI), were used as exercise therapy evaluation tools.

An often-discussed concept within Asian studies, medicine, and martial arts is *Ki*, or internal energy (i.e., *chi*, *c'hi*, or *qi*). *Ki* is described typically as an individual's vital energy that flows through their body along meridians, but is centered in the *DanJeon*, a point approximately three inches below the navel and three inches inside the lower abdomen. The movement and manipulations of *Ki* are the foci of Oriental medicine practices. In addition to herbal medicines, Oriental medicine uses acupuncture, acupressure, cupping, massage, and exercise to stimulate *Ki* in order to treat, and sometimes cure, various ailments and diseases. Some practices have been adopted by professional Western martial artists; proof of which can be seen occasionally on mixed marital art (MMA) fighters' bodies in the form of circular bruises left by suction cups after cupping therapy. Little studied by Western science (probably due to it being interpreted, at best, as a phenomenological experience and, at worst, mysticism), *Ki* is accepted as fact and a normal phenomenon in the ROK. Indeed, the ROK's National Health Insurance (NHIS) recognizes and insures Oriental medical practices just as equally as their Western counterparts.

Taekwondo, a Korean martial art turned Olympic sport, may be practiced for a plethora of health purposes, including interventions to improve overall physical health [19-22], body intelligence and brain connectivity [23], and obesity [24]. Moreover, "practicing martial arts [like taekwondo] aids students in the development aerobic endurance, muscular strength and endurance, joint flexibility, balance, and coordination" [25]. Taekwondo has also been adapted for various religious pursuits: various "Taekwondo for Christ," Taoism, and Buddhist mediation programs have sprung up across the world, all purporting taekwondo practice advances those practices.

Interest in complementary and alternative medicine (CAM) therapies began growing around the turn of the millennium [26]. Yoga is another Eastern practice that emphasizes stretching and breath control. It is a cost-effective, CAM therapy [27] that has shown to be an effective therapy for spondyloarthritis [28] and chronic lower back pain [29]. Dahn Taekwondo is a holistic practice advocated by Dahn Yoga & Health Centers (now called Body & Brain) that combines aspects of traditional Taekwondo and Dahn Yoga practices. Dahn Taekwondo practice is purported to have similar physical and spiritual benefits as those found in yoga. While Dahn Yoga business practices are suspect [30,31] and may not follow classical yoga practices, that does not invalidate the practice of Dahn yoga [32] or Dahn Taekwondo as potential therapy methods, especially since Dahn practices have been proven beneficial [33].

Despite ankylosing spondylitis being an autoimmune disease, we identified no previous studies on yoga's or taekwondo's influence on immune functions. Using established therapy methods for ankylosing spondylitis found in both Western and Oriental medicine practices, the Dahn Taekwondo Spondylitis Improvement Program (DTSIP) was created to address the lack of CAM therapies designed to improve immune functions in individuals with ankylosing spondylitis. Based on the perspective of the ROK's leading pathology, the aim of the study was to introduce and evaluate the DTSIP as a possible alternative intervention for ankylosing spondylitis therapy.

DTSIP also incorporated *Ki* therapy into its therapeutic strategy. As such, this research discusses the concepts of *Ki* and how various DTSIP exercises stimulates and facilitates the subject's therapy. DTSIP's *Ki* components were not, however, measured nor were they used to interpret this study's findings as they are, as of yet, beyond measurement by Western science. Their discussion herein is therefore meant to complement to the growing body of literature of the amalgamation of Oriental and Western medicine practices.

MATERIALS AND METHODS

Subject

The subject of this study was a 32-year-old male (age: 32 year; height: 183 cm; weight: 80 kg; body mass index: 23.89 kg/m^2) with ankylosing spondylitis. The purpose and practices of the study were explained to the subject and his parents, and they participated voluntarily; they were also free to withdraw at any time with no disadvantage.

Dahn Taekwondo Spondylitis Improvement Program (DTSIP)

DTSIP is an amalgamated program of standard Western medicine practices and CAM exercises based in Oriental medicine practices, yoga, and taekwondo. The subject performed the DTSIP 5 times a week for 90 minutes for 28 weeks. He conducted the training once a week with the researchers and 4 times a week with assistance from family and acquaintances. The training contents for the DTSIP are shown in Table 1 as well as illustrated and explained in Figures 1-5.

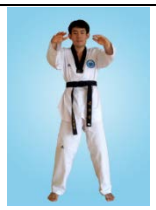
Table 1. Contents of the DTSIP training

Level	Program		Time	Target area	Expected effects
Warm up exercises (30 min)	*DanJeon* striking		300 reps, 5 min	Whole body	Relaxes whole body, increases body temperature, prepares for the training
	Jang-u-dong abdominal exercise		200 reps, 5 min		
	SuByeog (Waterfall) Striking		100 reps, 3 min		
	MuHanDae (Infinity) Turning		4 min		
	Onmom DuDeuliGi (Whole Body Tapping)		3 min		
	Shoulder rotations		5 min		
	Hip rotations		5 min		
Training (50 min)	Level I	Hip inflexions	20 min	Hip	Relaxes hip, balances the left and right sides of the body
	Level II	Shoulder inflexions	20 min	Shoulder, hip	Relaxes hip and shoulder joints, increases blood circulation
	Level III	*Wagong* position	5-10 min	Bottom	Discharges coldness and negative energy, improves immune system
Cool down exercise (10 min)	Rolling		20 reps	Whole body	Relieves stress, relaxes the whole body
	Relaxation pose		5 min		

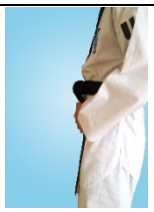
DTSIP: Dahn Taekwondo Spondylitis Improvement Program; *DanJeon*: the point in the lower abdomen where *Ki* energy is stored; *Ki*: internal energy

DTSIP training begins with warm-up exercises. As with any exercise program, a warm-up period is needed to prepare the body for exercise and to prevent injury. The purposes of DTSIP warm-up exercises includes improvement to improve overall mobility and flexibility in the spine as well as the flow of *Ki* along the body's meridians to prepare the subject for more strenuous exercises (Tables 4-5). Within the Oriental medical perspective, this study targeted, but did not measure, three meridians in order to increase *Ki* flow to: 1) the lungs, colon, stomach, and spleen (first meridian); 2) the heart, small intestine, bladder, and kidneys (second meridian); and 3) the liver (third meridian). Figure 1 shows and explains the DTSIP warm-up exercises used in this study.

Figure 2 shows and explains each Level I DTSIP exercise for hip inflexion. The purpose of these exercises is to improve overall mobility and flexibility in the spine and *Ki* flow with each exercise targeting either a particular region or the entire spine. The subject stands in modified taekwondo stances used as preparatory positions for punching. In the DTSIP, the stances allow the subject to maintain balance. In the majority of the DTSIP exercises, positioning the hands on the hips is intended to allow the subject to maintain balance (e.g., the knee inflexion and small back knee bend exercises) or, when palms and fingers are outstretched, facilitate the flow of *Ki* [24] (e.g., the side knee inflexion and the four shoulder pushing exercises).




DanJeon Striking: Standing with the feet about one shoulder-width apart, tap the *DanJeon* with both hands. This exercise intends to warm the body, loosen the shoulders, and improve digestion.

Jang-u-dong Abdominal Exercise: Standing with the feet about one shoulder-width apart, place both hands around the *DanJeon* and push them forward and backward only using the hips. This exercise intends to stimulate the small intestine; activate colon function; relieve constipation, diarrhea, tension, and abdominal stiffness caused by standing; and relax muscles in the lumbar region.


S*uByeog* (Waterfall) Striking: Standing with the feet about one shoulder-width apart and the knees bent slightly, clap the hands in front and behind the body at chest height alternatively. This exercise intends to relax the chest and back and improve the upper body's exercise capacity.

MuHanDae (Infinity) Turning: Standing with the feet about one shoulder-width apart and the knees bent slightly, face the palms outward and make large circles with the hands. The hips move in a figure-8 fashion, and the feet remain planted. The hands, arms, shoulders, and hip joints are relaxed, and the movement is natural. This exercise intends to balance the right and left sides of the body, stimulate the shoulders and hips, and improve flexibility and joint mobility.

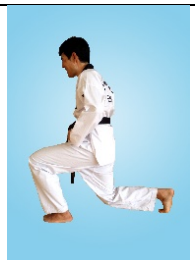
Onmom DuDeuliGi (Whole Body Tapping): Standing with the feet about one shoulder-width apart, strike the body in accordance with the path of the meridian as shown. This exercise intends to improve blood and *Ki* circulation to the skin and around the body.

Shoulder Rotations: Standing with the feet about one shoulder-width apart and the knees bent slightly, place the hands on the shoulders and rotate the elbows in an inward-to-outward manner. This exercise intends to relax stiff shoulders and increase overall range of motion in the upper body.

Hip Rotations: Stand upright and lift the knee forward and then rotate it outward. Ensure the back stays perpendicular to the ground, and the hands are held at the waist. Reverse the motion and alternate sides. This exercise intends to improve lower lumbar and hip mobility, strength, and general lower body flexibility.

Figure 1. DTDIP warm-up exercises. DTSIP - Dahn Taekwondo Spondylitis Improvement Program; *DanJeon*: the point in the lower abdomen where *Ki* energy is stored; *Ki*: internal energy.


Knee Inflexion: Stepping one foot forward, place fists on the pelvis and turn the front foot 45° inward. Keeping it straight, push forward with the back leg and spread the hip joints. Ensure the back stays perpendicular to the ground and the fists are held at the waist with palms upward. Alternate sides. This exercise intends to improve hip flexibility and connect the meridians in the body.

Forward Lunges: Step one foot forward, place fists on the pelvis, and turn the front foot 45° inward. Lower the back knee to about 10 cm off the ground while bending the forward knee. Ensure the back stays perpendicular to the ground and the fists are held at the waist with palms upward. Alternate sides. This exercise intends to improve knee and hip mobility as well as strengthens the spleen and liver meridians.

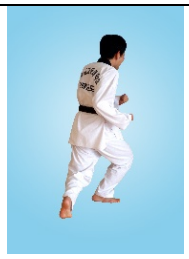

Side Knee Inflexion: Spread the feet about two shoulder-widths apart and bend the knees while keep the feet pointing straightforward (this forms a taekwondo horse-riding stance). Ensure the back stays perpendicular to the ground and the fists are held at the waist with palms upward. Then, spread push the hands forward with palms outward while curving the pelvis and thoracic area inward. This exercise intends to elongate the spine as well as facilitate *Ki* flow.


Half-knee Inflexion: Spread the feet about two shoulder-widths apart and bend the knees while keep the feet pointing straightforward (this forms a taekwondo horse-riding stance). Ensure the back stays perpendicular to the ground and the fists are held at the waist with palms upward. Bend one knee to 90° or until the other knee is straightened. Alternate sides. This exercise intends to improve knee strength and flexibility.

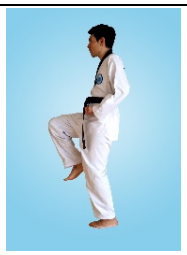

Small Back Knee Bend: Step one foot forward and place only the ball of the foot down while bending the back knee (this forms a taekwondo *beom sogi* or tiger stance). The thighs should be pushed outward, preventing the knees from turning inward. Ensure the back stays perpendicular to the ground and the fists are held at the waist with palms upward. Alternate sides. This exercise intends to balance the body and activate the spleen meridian.


Back Knee Bend: Step one foot forward and rotate the back foot so the toes point 90° outward (this forms a taekwondo back stance). Ensure the back stays perpendicular to the ground and the fists are held at the waist with palms upward. Alternate sides. This exercise intends to balance the body and stimulate the three main meridians.

Figure 2. Level I (hip inflexion) DTSIP training. DTSIP - Dahn Taekwondo Spondylitis Improvement Program; *Ki*: internal energy – downhill …

Twisting Stance: Step forward and point the toes of the forward foot 90° outward, then bend the back knee until it is approximately 10 cm above the ground, while ensuring the back stays perpendicular to the ground. The fists are held at the waist with palms upward. Alternate sides. This exercise intends to improve *Ki* circulation in all of the meridians, blood circulation in the lower body, and knee and hip strength and flexibility. Caution is required: the subject may lose balance during this exercise and thus may need an assistant.

Standing Knee Bends: Standing upright with the feet together, raise one knee straight upward. The fists are held at the waist with palms upward. Alternate sides. This exercise intends to improve balance and overall leg strength. Caution is required: the subject may lose balance during this exercise and thus may need an assistant.


Outward Knee Pushing: Sitting on the ground with the knees bent (ideally with the feet flat on the floor), have an assistant straddle the subject's outstretched legs. The assistant bends their knees to maintain balance while the subject pushes the sides of their knees outward and exhales. The assistant provides moderate resistance. This exercise intends to improve core, back, and outer knee strength.


Inward Knee Pushing: Sitting on the ground with knees bent (ideally with the feet flat on the floor), have an assistant standing inside the subject's outstretched legs. The assistant bends their knees to maintain balance while the subject pushes the sides of their knees inward and exhales. The assistant provides moderate resistance. This exercise intends to improve core, back, and inner knee strength.

Forward Leg Push: Sitting on the ground with legs shoulder-width apart, knees bent (ideally with the feet flat on the floor), and arms hugging the legs, have an assistant kneel on one knee in front and between the legs. The subject pushes the body forward, while the assistant pushes both shoulders back, providing moderate resistance. This exercise intends to improve abdominal, back, and neck strength while improving balance.

Backward Leg Push: Sitting on the ground with legs shoulder-width apart, knees bent (ideally with the feet flat on the floor), and arms hugging the legs, have an assistant kneel on one knee behind the subject. The subject pushes the body forward, while the assistant pushes both shoulders forward, providing moderate resistance. This exercise intends to improve abdominal, back, and neck strength while improving balance.

Figure 2. Level I (hip inflexion) DTSIP training. DTSIP - Dahn Taekwondo Spondylitis Improvement Program; *Ki*: internal energy

Figure 3 shows and explains each Level II DTSIP exercise for shoulder inflexion. Level II DTSIP training isolates the upper thoracic area and shoulders.

Figure 4 illustrates the *wagong* position, the sole exercise of the third level of the DTSIP. From a Western medicine perspective, this position allows blood to drain away from the extremities where it accumulates during exercise. Oriental medicine, on the other hand, believes that the *wagong* position improves the flow of *Ki* through the subject's extremities. To aid with the flow of *Ki*, the subject is instructed to concentrate on breathing and be conscious of *Ki* energy flowing through the extremities to the *DanJeon*.

Figure 5 shows the DTSIP's cool-down exercises, which are based on yoga poses and motions. As with any exercise program, a cool-down period is necessary to return the body to normal levels of operation, reduce the heartrate and breathing, lower the body temperature slowly, as well as prevent blood from gathering in the lower extremities. Within the Oriental medicine paradigm, cooling down returns the nature flow of *Ki* in the case it may have accumulated in the particular body part or area exercised; in the case of DTSIP, this would usually be the spine. Furthermore, ankylosing spondylitis causes shoulder joint, hip, and neck hardening, making it difficult for *Ki* to flow from the *DanJeon* to the extremities. This cool-down period is thus intended to facilitate the free flow of *Ki* again.

Outward Shoulder Pushing: Standing with the feet about shoulder-width apart and the knees bent slightly, straighten the arms forward at shoulder height with palms facing inward. The assistant stands in front of the subject with their palms on the back of the subject's hands. The subject pushes outward against the assistant's hands, and the assistant provides moderate resistance. This exercise intends to strengthen the shoulders and upper thoracic area and facilitate *Ki* flow.

Inward Shoulder Pushing: Standing with the feet about shoulder-width apart and the knees bent slightly, straighten the arms forward at shoulder height with palms facing inward. The assistant stands in front of the subject with arms outstretched inside the subject's arms. The subject pushes inward against the assistant's hands, and the assistant provides moderate resistance. This exercise intends to strengthen the shoulders and upper thoracic area and facilitate *Ki* flow.

Upward Shoulder Pushing: Standing with the feet about shoulder-width apart and the knees bent slightly, straighten the arms forward at shoulder height with palms facing downward. The assistant stands in front of the subject with hands on top of the subject's forearms. The subject pushes upward against the assistant's hands, and the assistant provides moderate resistance. This exercise intends to strengthen the shoulders and upper thoracic area and facilitate *Ki* flow.

Downward Shoulder Pushing: Standing with the feet about shoulder-width apart and the knees bent slightly straighten the arms forward at shoulder height with palms facing downward. The assistant stands in front of the subject with hands under the subject's forearms. The subject pushes downward against the assistant's hands, and the assistant provides moderate resistance. This exercise intends to strengthen the shoulders and upper thoracic area and facilitate *Ki* flow.

Figure 3: Level II (shoulder inflexion) DTSIP training. DTSIP - Dahn Taekwondo Spondylitis Improvement Program; *Ki*: internal energy

Wagong Position: Laying on the back with arms outstretched and palms facing upward, bend the knees and ankles at right angles. The legs should be 5-7 cm part. This exercise intends to drain blood away from the extremities and improve *Ki* flow.

Figure 4: Level III (*Wagong* position) DTSIP training. DTSIP - Dahn Taekwondo Spondylitis Improvement Program

Rolling: Sit down, pull the knees to the chest, hold the knees with both hands, and tuck the chin forward. Then, roll back and forward along the spine. Next, when on the back, roll side to side. Take one breath for each roll, inhaling when rolling in one direction and exhaling when rolling in the opposite direction. This motion intends to stimulate the entire spine as well as improve digestive functions.

Relaxation Pose: Laying down, spread the arms at 45° from the body with palms and outstretch the legs, allowing the feet to rotate outward. The subject should examine the entire body mindfully, starting from the top of the head and going down to the tips of the toes. Breathing should be slow and relaxed, and the head should feel cool and the body and extremities warm. This posture intends to allow the subject to normalize their mind and body for regular daily activities.

Figure 5: DTSIP cool-down exercises. DTSIP - Dahn Taekwondo Spondylitis Improvement Program

Measurements and blood sampling

The subject's height and weight were measured pre- and post-test of the DTSIP program. C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), platelet, white blood cells (WBC), and leukocyte levels were determined. The subject's spinal and joint ranges of motion were also measured.

Body Mass Index (BMI)

The height and weight of the subject were measured. From those variables, the subject's body mass index (BMI) was calculated.

Range of motion of spine and joints

BASMI is an established method consisting of five measurements that verify the range of spine movement in patients with ankylosing spondylitis [34]. From these measurements, clinical changes in spinal movement are ascertained. A modified BASMI was used for this study.

The subject's tragus to wall (TWD) distance was first determined in accordance with standard BASMI methodology. TWD is an indicator for the development of flexion deformation of the spine and proper posture. The subject stood with his back and heels touching a wall, feet hip-distance apart, and chin tucked to his chest. A standard tape measure was used to determine the distance from the wall to his tragus in cm. The measurements were then recorded.

Second, the lumbar side flexion (LSF) measurement was taken in accordance with standard BASMI methodology. LSF is an index to assess the severity of a subject's chest and lumbar spine immobility. The subject stood against a wall with his back and heels touching it, feet hip-distance apart, and arms and fingers straight down his sides. The distance from the tip of his middle fingers to the ground was determined with the tape measure perpendicular from the ground to their fingers. Then, he bent as far as possible to each side while maintaining flush contact to the wall with his back and his middle finger down the side of his leg. The distance from his middle finger to the ground was taken again, and the difference of the two measurements was recorded. The measurements were then recorded.

Third, the modified Schober's test, sometimes called the lumbar flexion (LF) test, was conducted to measure the curve of the subject's waist in accordance with standard BASMI

methodology. The subject stood upright with feet about hip-distance apart. Three successive marks were placed along the subject's spine: 1) on the posterior superior iliac spine (PSIS) line, 2) 5 cm below the PSIS line mark, and 3) 10 cm above the PSIS line mark. The top- and bottommost marks were then 15 cm apart. The subject then bent forward as far as possible trying to touch his toes while keeping his knees straight. The distance between the top and bottom marks were measured, the difference between the original 15 cm distance and the new distance was recorded. If the difference is more than 5 cm, it is judged to be normal; if it is less than 5 cm, the subject is considered to have limited mobility in the lumbar region. The subject's measurements were then recorded.

Fourth, the subject's intermalleolar distance (IMD) was measured in accordance with standard BASMI methodology. First, he laid down supinely and spread his legs about should-width apart with his hips abducted fully. The distance between his medial malleoli was then measured. The subject then stood with legs spread as far as possible and the distance between his medial malleoli was measured again. The measurements were then recorded.

In standard BASMI methodology, cervical rotation (CR) is determined next. This measures the flexibility of the cervical vertebrae by measuring the rotation angle of the neck. The subject lays supinely with their head in a neutral position and his forehead horizontal. A gravity goniometer is placed on the forehead, and the subject rotates their head as far as possible, while without moving the shoulders, and the distance rotated is recorded.

In the current study, it was felt that measuring the subject's range of motion in his cervical spine, thoracic and lumber region as well as his shoulders and hips would provide a more accurate account of his physical limitations than the standard BASMI CR measurement. Creating an appropriate therapy program, estimating a prognosis, and judging the effectiveness of the therapeutic effect were possible after taking these measurements. Consequently, we also measured the subject's range of motion in his cervical spine, thoracic and lumber regions, and his shoulder and hips in addition to the first four BASMI basic items. These measurements showed more accurately the extent of the subject's limited of ranges of motion and how they were related to his performance impairments, such as walking or other daily activities. To do this, the average value of two measurements made with a semicircular protractor (Bluebird, China; product ID: JN15-90) was used. First, the cervical spine's range of motion was measured by determining the subject's front, back, left, and right rotations. The left and right rotations of the cervical vertebrae in the center of the head were also measured. His cervical rotation was measured by rotating his head left and right. All measurements were recorded. The front, back, left and right flexion, and left and right rotation of chest/lumbar spine range of motion were measured with a semicircular goniometer (Bluebird, China; product ID: JN15-90). The subject's left and right shoulder ranges of motion were measured by lifting the arm to its maximum position. Left and right hip joint motions were measured by the maximum elevation angle of the lifted knee when standing.

RESULTS

Data were analyzed by using Microsoft Office Excel 2013, and the differences in each measurement variable before and after applying the DTSIP were analyzed. The subject's pre- and post-test results are shown in Table 2. His pre- and post-test ESR results decreased approximately 77.01% (67 mm/hr) after the DTSIP. The subject's pre- and post-test platelet levels also decreased by about 29.27% (120 $^{3}/\mu\ell$). His pre- and post-test white blood cell (WBC) count decreased approximately 11% (1.02 $^{3}/\mu\ell$). In addition, the DTSIP effected all but one of the subject's white blood cell subtypes: basophil (pre-test=0.4%, post-test=0.5%), eosinophil (pre-test=2.8%, post-test=2.1%), neutrophils (pre-test=56.6%, post-test=56.6%; i.e., no change), lymphocyte (pre-test=35.2%, post-test=32.5%), and monocyte (pre-test=5.6%, post-test=6.2%). The subject's pre- and post-test BASMI measurements are contain in Table 3. Results show the subject improved in flexibility in all areas. The subject's pre- and post-test cervical ranges of motion are includes in Table 4. Results show the subject improved in flexibility in all areas. The subject's pre- and post-test thoracic and lumbar ranges of motion are contain in Table 5. Results show the subject improved in flexibility in all areas measured. The subject's pre- and post-test shoulder ranges of motion are includes in Table 6. Results show the subject

improved in flexibility in both areas measured. The subject's pre- and post-test hip ranges are contain in Table 7. Results show the subject improved in flexibility in both areas measured.

Table 2. Pre- and post-test differences in CRP concentration

Indicator	Pre-test	Post-test	Reference value
CRP	6.95 mg/dL	1.79 mg/dL	0.00-0.49 mg/dL
ESR	87 mm/hr	20 mm/hr	0-9 mm/hr
Platelet levels	410 $^3/\mu\ell$	290 $^3/\mu\ell$	130-400 $^3/\mu\ell$
WBC	9.26 $^3/\mu\ell$	8.24 $^3/\mu\ell$	4.0-10.0 $^3/\mu\ell$

CRP: C-reaction protein, ESR: Erythrocyte sedimentation rate. WBC: white blood cell level

Table 3. Pre- and post-test results in BASMI measurements; units in cm

Indicator	Measurement area	Pre-test	Post-test
TWD	Cervical, thoracic	34	17
LSF	Thoracic, lumbar	2	5
LF/MSF	Thoracic, lumbar	0	5
IMD	Malleolus	16	0

BASMI: Bath Ankylosing Spondylitis Metrology Index, TWD: tragus to wall distance, LSF: lumbar side flexion, LF/MSF: lumbar flexion/modified Schober flexion, IMD: intermalleolar distance

Table 4. Pre- and post-tests results in cervical ranges of motion; units in degrees (°)

Indicator	Reference value	Pre-test	Post-test
Front flexion	45	4	8
Back flexion	45	8	8
Left flexion	45	2	4
Right flexion	45	2	4
Left rotation	80	2	6
Right rotation	80	2	8

Table 5. Pre- and post-tests results in thoracic and lumbar ranges of motion; units in degrees (°)

Indicator	Reference value	Pre-test	Post-test
Front	90	30	40
Back	30	0	10
Left	30	6	12
Right	30	10	12
Left rotation	30	6	12
Right rotation	30	8	12

Table 6. Pre- and post-tests results in shoulder ranges of motion; units in degrees (°)

Indicator	Reference value	Pre-test	Post-test
Left shoulder	180	15	93
Right shoulder	180	85	105

Table 7. Pre- and post-tests results in hip range of motion

Indicator	Reference value	Pre-test	Post-test
Left hip	120	30	104
Right hip	120	5	92

DISCUSSION

For this study, we developed the DTSIP and applied it to a Korean male in his 30s with ankylosing spondylitis for 28 weeks, and then analyzed its effects. The subject's CRP levels were reduced from 6.95 mg/dL to 1.79 mg/dL after intervention (about 74%, 5.16 mg/dL). His ESL decreased from 87 mm/hr (pre-test) to 20 mm/hr (post-test), a difference of about 77% (67 mm/hr). His platelet level decreased from 410 $^3/\mu\ell$ (pre-test) to 290 $^3/\mu\ell$ (post-test), a difference of about 29% (120 $^3/\mu\ell$). His pre- and post-test CRP, ESR, and platelet values indicate DTSIP had a positive effect on his blood inflammation level. In a previous study, Son (2009) reported that 8 female subjects (aged 50+) with rheumatoid arthritis reported significant decreases in CRP and ESR after performing tachycardia exercises for 90 minutes twice a week for 6 weeks [34]. As rheumatoid arthritis and ankylosing spondylitis are both inflammatory rheumatic diseases, the results of the current study seem to support Son's (2009) findings despite the lack of a direct correlation between the two studies [34].

The subject's WBC level decreased from 9.26 $^3/\mu\ell$ (pre-test) to 8.24 $^3/\mu\ell$ (post-test), a difference of about 11% (1.02 $^3/\mu\ell$). When considering that a normal white blood cell count is 4.0-10.0 $^3/\mu\ell$, the subject's decrease in WBC level can be considered a potential positive effect of DTSIP despite that both pre- and post-test levels were within normal ranges. Furthermore, there was no significant difference between the WBC subtypes (i.e., basophil, eosinophil, neutrophils, lymphocyte, and monocyte).

A previous study [35] compared a healthy individual with a subject with ankylosing spondylitis and, although it did not analyze the effect of exercise therapy, it reported the person with ankylosing spondylitis showed increased ($p<0.05$) leukocyte, neutrophil, platelet, and monocyte counts after conducting an immunologic analysis of clinical features. In the results of our study show our subject had an approximate 11% decrease in leukocyte after applying an exercise program, thus indicating the DTSIP may have a positive effect on inflammation and immune function.

The results of the BASMI measurements taken to examine the changes in the subject's spinal range of motion were as follows: TWD decreased from 34 cm to 17 cm, LSF improved from 2 cm to 5 cm, LF improved from 0 cm to 5 cm, and IMD decreased from 16 cm to 0 cm. All measurements showed an improvement in the range of motion. Analay et al. [11] had patients with ankylosing spondylitis perform stretching and cardio exercises for 50 minutes 3 times a week for 6 weeks and also found that their subjects' TWD, LF, and IMD measurements improved, but not as much as within the current study. They also reported a positive effect on their subjects' depression levels, physical functions, and psychological status. Ince et al. [36] had patients with ankylosing spondylitis perform aerobics, stretching, and cardio exercises for 50 minutes 3 times a week for 3 months and found a significant increase in occiput to wall distance (OWD; an index of flexibility of cervical spine and thoracic vertebrae) and finger to floor distance (FFD, an index of lumbar flexibility) [37]. Although our subject's psychological status was not part of this study, the similar physical results in the current study and the Analay et al. [11] and Ince et al. [36] studies imply DTSIP could produce similar psychological results.

Fernández-de-Las-Peñas et al. [39] had patients with ankylosing spondylitis perform exercises that strengthens muscle, flexibility, and the respiratory system for 12 months and found that TWD, LSF, LF, IMD, and CE were all significantly increased [39]. In addition to BASMI, our study also measured our subject's spinal ranges of motion (i.e., front, back, left, right, left rotation, right rotation) and the ranges of motion of his shoulders and hips. His cervical vertebra movement range, range of thoracic and lumbar movement, and shoulder and hip joint range of motion all increased.

Typical ankylosing spondylitis therapies focus the areas experiencing pain, such as neck or back. Yet, to properly understand the human spine, the balance of the hips, which are its root, and the shoulders, which are near the spine's apex, need to be prioritized. The vertebral line is an indication of a person's proper alignment of the hip, spine, and shoulders. Alternatively, improper alinement of the shoulders and hips distort the vertebral line, necessitating the inclusion of shoulder and hip exercises in a therapy plan. We included shoulder and hip joint therapies in the DTSIP by first engaging them in warm-up exercises, then performing various strengthening exercises, and finally ensuring a proper cool-down period for them. Our subject's results indicate that DTSIP exercises relaxed his hip and shoulder joints and improved his cervical spine and thoracic and lumbar spine range of motion.

CONCLUSIONS

The DTSIP is an amalgamation of different aspects of Dahn Yoga, Dahn Taekwondo, and standard and modified exercise therapy plans. This case study consisted of only one male subject in his 30s. However, our results indicate DTSIP had positive effects on our subject's spinal mobility, flexibility, and strength. His overall improvement indicates that DTSIP could provide a CAM therapy for individuals suffering from ankylosing spondylitis.

Although DTSIP exercises are not necessarily standard taekwondo practices, many of the exercises and stances in it are found in taekwondo classes. Furthermore, since taekwondo possesses many different learning objectives [40], DTSIP can be seen as one (of many) ways to practice taekwondo. Thus, the appropriation of the taekwondo name may mislead some practitioners in thinking DTSIP is the "proper" way to practice taekwondo or that the plan is in of itself wholly taekwondo. Nevertheless, the subject's improved spinal health hints that utilizing DTSIP exercises may facilitate taekwondo practice as well as the disabling effects of ankylosing spondylitis. As such, regular taekwondo practitioners and school owners may use DTSIP exercises as part of their routine practice, while individuals with ankylosing spondylitis may use them for therapeutic purposes.

Future DTSIP studies must have larger and more diverse populations that consider subjects' gender, age, disease duration, and other factors commonly associated with ankylosing spondylitis and other autoimmune diseases that were not discussed within this study. Since other ankylosing spondylitis studies have also examined the effect of physical exercise on their subjects' depression, there is precedent for similar studies on DTSIP as well. Finally, it is hoped that *Ki*, an Oriental medicine concept that was used to create the DTSIP and consequently discussed but not tested in this study, can be the focus of future ankylosing spondylitis studies. However, that will have to wait until a randomized, controlled study that quantifies *Ki* is developed. This study only wishes to advance the notion that *Ki* could be an effective component in ankylosing spondylitis and other spondyloarthritis disease therapy programs.

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