

## Physiological Benefits of 24-style Taijiquan Exercise in Middle-aged Women

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**Abstract** This study examined the physiological benefits of 24-style Taijiquan (24TJQ) exercises by comparing heart rate (HR), respiratory rate (RR), exercise intensity, electroencephalograph, surface electromyography and surface thermograph, as well as the results of physical fitness test in 20 middle-aged women (10 skilled participants and 10 novices). The data from the skilled participants showed greater values in sit-ups ( $p < 0.01$ ), side step ( $p < 0.01$ ) and stand trunk flexion ( $p < 0.05$ ), moreover, the statistic data demonstrated not only greater HR ( $p < 0.05$ ) or lower RR during exercise, but also higher beta%-power during the experiment, higher alpha%-power in the eye-closed period and central alpha dominant after exercise. These results suggest that 24TJQ is effective to promote physiological benefits in middle-aged women. It attracts strong interest and is helpful to induce psychological relaxation and mental concentration. *J Physiol Anthropol Appl Human Sci* 22 (5): 219–225, 2003 <http://www.jstage.jst.go.jp/en/>

**Keywords:** 24TJQ, exercise intensity, respiratory rate, electroencephalograph, surface electromyography

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### Introduction

Quality of life is closely related to mental state as well as physical fitness, and exercise or sports is of assistance to both of mental state and physical fitness. Taijiquan (TJQ), a traditional Chinese conditioning exercise, has become an eye-catching exercise for its beneficial effects physiologically and psychologically, and 24-style Taijiquan (24TJQ),—gathering all the advantages of other styles of TJQ, is the most representative and popular one in China. (Taijiquan total collection, 1990).

Till now, there have been a number of studies concerning the physiological effects of TJQ on cardio-respiratory function (Schneider and Leung 1991; Brown et al., 1989; Hong et al., 2000), physical fitness (Hong et al., 2000; Lan et al., 1998), body composition (Lan et al., 1996) and immunity improvement (Sun et al., 1989) as well as the rehabilitation of cardio-respiratory function (Channer et al., 1996; Lan et al.,

1999), arthritis (Farrell, 1999) and high blood pressure (Deborah, 1999) etc. In addition, Jin (1989, 1992) reported that practice of TJQ was helpful to lessen tension, depression, anger, fatigue, confusion and state-anxiety, and made the practitioners feel more vigorous and lessened total mood disturbance. Brown et al. (1995) also concluded that TJQ exercise was effective to promote psychological benefits. However, these researches applied the same questionnaire methods based on subjective feelings, we have found that no report, to our knowledge, has used objective method, such as electroencephalograph (EEG), to reflect its psychological benefits, especially on its relaxation and concentration effects. This is possibly because traditional EEG measurement often needs a thoroughly quiet state. In this study, after fully considering the restricting condition of EEG measurement, we tried to use a telemeter system to avoid the noise in EEG caused by TJQ exercise.

However, the most literatures about the physiological effects was to undertake a short-term training (0.5~1 yr) research methodology that is not sufficient to reveal the long-term training effects of TJQ, which are more expected by the practitioners. Therefore, it is necessary to compare the difference among various methodologies on the long-term physiological effects.

At the present study, a comparison between a skilled group and a novices group were run to examine the different physiological effects of 24TJQ in middle-aged women. Heart rate (HR), exercise intensity, respiratory rate (RR) and physical fitness test were used to reveal its effects on physiological function and physical fitness, and EEG to reveal its psycho-physiological benefits. Moreover, for describing motion characteristics and surface temperature response, we applied surface electromyography (EMG) and surface thermograph (ST) techniques. We hypothesized that 24TJQ is not only effective to improve physical fitness and to promote physiological benefits, but can also bring some favorite psycho-physiological effects.

## Materials and methods

### Subjects

20 healthy and physically active females were volunteer participants. They were divided into a skilled group (SG: N=10) and a novices' group (NG: N=10) according to their 24TJQ experience time. The SG was recruited from local TJQ enthusiasts, while the NG started TJQ a year ago. The Human use committee at the School of Health and Sport Sciences, Osaka University approved this study protocol and written informed consent was obtained from all of the subjects.

### The measurements and processing materials

Physical characteristics, average height, weight and body fat rate (%fat) were compared between the two groups (Table 1), %fat measurement was taken by bio-impedance method (Komiya, 1997) with TBF-401 (Tanita Co. LTD. Tokyo, Jpn.). Physical fitness test including Grip strength, Vertical jump, Side step, Standing trunk flexion and Sit-ups were conducted according to the 4th edition of "The standard value of Japanese physical fitness." (1989).

All subjects were required to sit quietly for 3min before (rest) and after (recovery) 24TJQ exercise respectively. For the exercise, it took 6 min. The rest period consisted of two phases including an order of 2 min eye-opened phase and 1 min eye-closed phase. And the recovery period also consisted of two phases including an order of 1min eye-closed phase and 2 min eye-opened phase. HR, RR, EEG and EMG were concurrently measured by using Telemeter System EEG 4518 Firing Unit QI-403A (Nihon Kohden, Tokyo, Jpn.). Chest bipolar induction method was applied to record HR. EEG was measured by bipolar induction method with 4 cup-electrodes (Ag-AgCl) attached on central (C3, C4) and occipital region (O1, O2) as the induction electrodes. The forehead center between eyebrows was taken as earth electrode. The localization was determined by international 10-20 systems. EEG data analysis was conducted by using multiple analysis programs of physical information, BIMUTAS (Kiltuseikomuteltuku Ltd. Co.). The mean power spectrums of delta (0.5–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (13–30 Hz) and gamma (30–50 Hz) wave in every 30 sec were analyzed by using FFT (FOCUS: Fast Fourier Transform) to calculate the relative alpha and beta activity (alpha%-power, beta%-power). Surface EMG was measured on the following 6 muscles (all on the right): trapezius m., latissimus dorsi m., gluteus maximum m., quadriceps m. of thigh, tibial m., anterior and triceps of calf. 2 cup-electrodes (Ag-AgCl) with an interval of about 2 cm were stuck along with the arrangement direction of muscle fibers on avoidance of motor points. The integrated electromyography (iEMG) was calculated every 0.2 sec from the raw EMG. ST was measured by using Thermography-INF-1200 (Nihon Kohden, Tokyo, Jpn.). Face, neck, right/left hand, right/left leg were chosen as measuring areas. 10 films were taken including 1 film before the exercise and 1 film/min during the exercise and the average

surface temperature was calculated out. A video camera recorded 24TJQ practice in order to do the individual motion analysis.

$\dot{V}O_{2\text{submax}}$  or  $\dot{V}O_{2\text{max}}$  were measured on a motor-driven treadmill through a continuous incremental exercise test, which consisted of three jogging stages at the speed of 100 m/min, 150 m/min, and 200 m/min respectively. After jogging 4 min in each stage, the speed was increased by a rate of 20 m/min and the slope by a rate of 2% until intolerable dyspnea or muscular fatigue occurred. The criteria for  $\dot{V}O_{2\text{max}}$  were established as one or more of the following appears: (a) a plateau in oxygen consumption (i.e., successive assessments with changes no greater than  $\pm 2$  ml), (b) a respiratory exchange ratio greater than 1.0, (c) heart rate equal to or exceeding the age-predicted maximum. All subjects achieved one or more of these criteria. The  $\dot{V}O_{2\text{max}}$  value was used in establishing the intensity of 24TJQ exercise based from the linear correlation between  $\dot{V}O_{2\text{max}}$  and HR. The expired air was analyzed through breath-by-breath system by using Respiratory metabolism exam equipment (2900; SensorMedics Co., Jpn.).

### Statistics

One-way analysis of variance and paired t-test, when applicable, were performed to compare the mean HR, RR, exercise intensity, alpha%-power, beta%-power, ST, physical characteristics and physical fitness test before, during and after 24TJQ exercise. Differences were considered significant at  $p < 0.05$  in all analysis except for the changes of alpha%-power between central and occipital region during and after exercise ( $p < 0.10$ ).

## Results

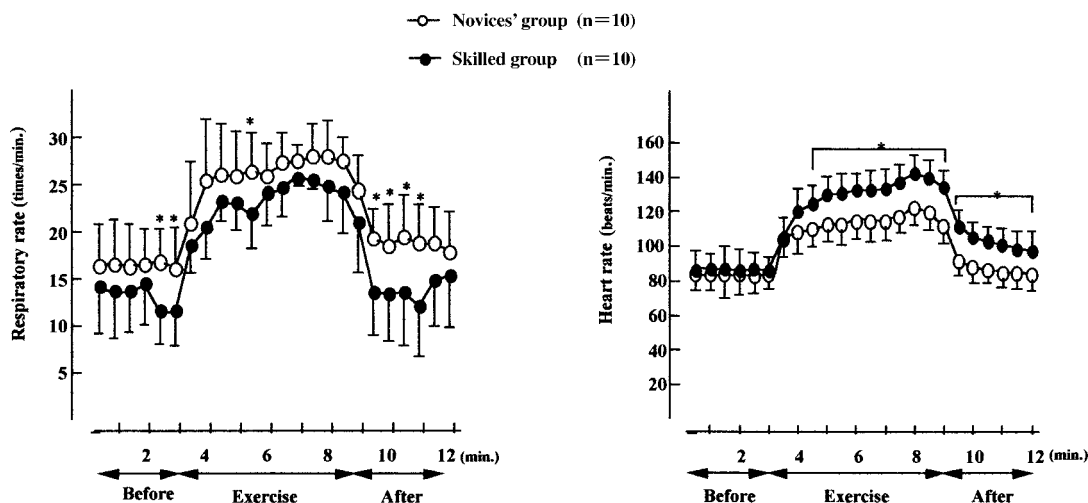
Table 1 shows the average values of physical characteristics and physical fitness test in both groups. Although no significant differences occurred in grip strength and vertical jump, the data from the SG showed greater values in sit-ups ( $p < 0.01$ ), side step ( $p < 0.01$ ) and stand trunk flexion ( $p < 0.05$ ) than from the NG.

Figure 1 shows the variations of average HR and average RR in both groups. RR showed lower values in the SG than in the NG, the average times/min in the SG were  $13.3 \pm 2.2$ ,  $24.3 \pm 2.4$  and  $13.1 \pm 2.5$  times/min, while those in the NG were  $16.2 \pm 1.2$ ,  $25.3 \pm 1.7$  and  $19.5 \pm 1.2$  times/min before, during and after exercise respectively. It showed significantly lower from the SG on the last minute before exercise ( $p < 0.05$ ) and on the first 2 minutes after exercise ( $p < 0.05$ ). Although both groups' RR increased during exercise, it increased bigger in the NG than in the SG. On the contrary, the SG showed significantly higher HR than the NG during and after exercise ( $p < 0.05$ ). The average HR during exercise was  $137.8 \pm 6.4$  bpm (112–142) for the SG and  $117.7 \pm 6.5$  bpm (108–126) for the NG. Based on the linear correlation between  $\dot{V}O_{2\text{max}}$  and HR, the relative intensity of 24TJQ exercise was calculated out. The average intensity of 24TJQ was  $60.4 \pm 8.6\%$   $\dot{V}O_{2\text{max}}$  for the

**Table 1** Mean values of physical characteristics and physical fitness

	Skilled Group (n=10)	Novices' group (n=10)
	Mean±SD.	Mean±SD.
Age (yr.)	50.5±5.45	53.6±4.9
Height (cm)	158.5±2.7	155.7±5.3
Weight (kg)	61.7±6.9	60.1±7.2
% body fat (%)	28.5±6.9	27.6±4.8
Experience time (yr.)	6.3±0.8**	0.8±0.4
Grip strength (kg)	25±3.9	24.7±4.3
Sit-ups (times)	11.3±3.1**	3.6±5.3
Vertical jump (cm)	33±4.3	29.3±7
Side step (times)	38.8±3.1**	30±4.2
Standing trunk (cm)	15.9±5.3*	7.8±6.1

Note. Values are means±SD. \*p<0.05, \*\*p<0.01



**Fig. 1** Comparisons of respiratory rate and heart rate between the novices' group and the skilled group before, during and after 24TJQ exercise. Values are mean±S.D. \*p<0.05.

SG and  $49.3 \pm 10.1\%$   $\dot{V}O_2\max$  for the NG, in which the SG showed significantly higher value than the NG ( $p < 0.05$ ).

Figure 2 shows the average variations of alpha%-power and beta%-power for both groups. Nearly the same values of alpha%-power appeared in 2 groups during exercise, but the SG showed significantly higher one in eye-closed rest and eye-closed recovery period ( $p < 0.05$ ). In addition, in the SG the data showed a tendency of higher beta%-power during experiment than in the NG.

Figure 3 shows the distribution variation of alpha%-power between central and occipital region during and after exercise. There was no significant change in NG between occipital and central region, but in the SG there was a significant increase of alpha%-power in central region compared to occipital region after exercise ( $0.05 < p < 0.10$ ).

For reflecting the individual characteristics of iEMG, two cases from each group were taken out (Figure 4) when doing the same motions. By comparing iEMG on quadriceps m. of thigh and gluteus maximum m., the skilled participants

displayed a smooth or stable variation pattern, while the novices showed a sharp or unstable variation pattern. This difference could be often found from other individuals, so it can be taken as a common feature to assess the expertise in EMG methodology.

The average surface temperatures before and after exercise indicated  $34.6 \pm 0.9^\circ\text{C}$  and  $36.5 \pm 0.3^\circ\text{C}$  in the SG, and  $34.4 \pm 1.3^\circ\text{C}$  and  $35.5 \pm 0.3^\circ\text{C}$  in the NG, respectively. The SG showed a significant increase after exercise ( $p < 0.05$ ). Although in both groups the statistic data showed almost equal values before exercise, but in the SG the values was greater than in the NG ( $p < 0.05$ ) after exercise.

## Discussion

Aging is connected with the decrease of muscle strength; and the lack of muscle strength may hinder performance of functional tasks. Although resistance training can enhance muscle strength in older adults (Fatarone et al., 1990; Nichols

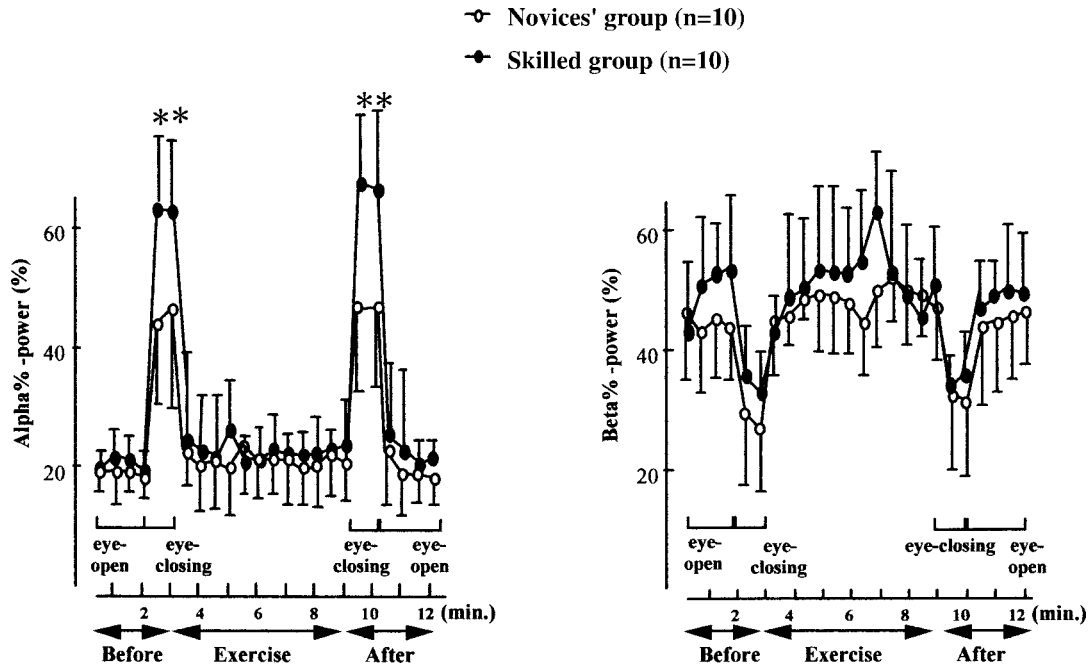


Fig. 2 Comparisons of appearance rate in alpha%-power and beta%-power between the novices' group and the skilled group before, during and after 24TJQ exercise. Values are mean  $\pm$  S.D. \* $p < 0.05$ .

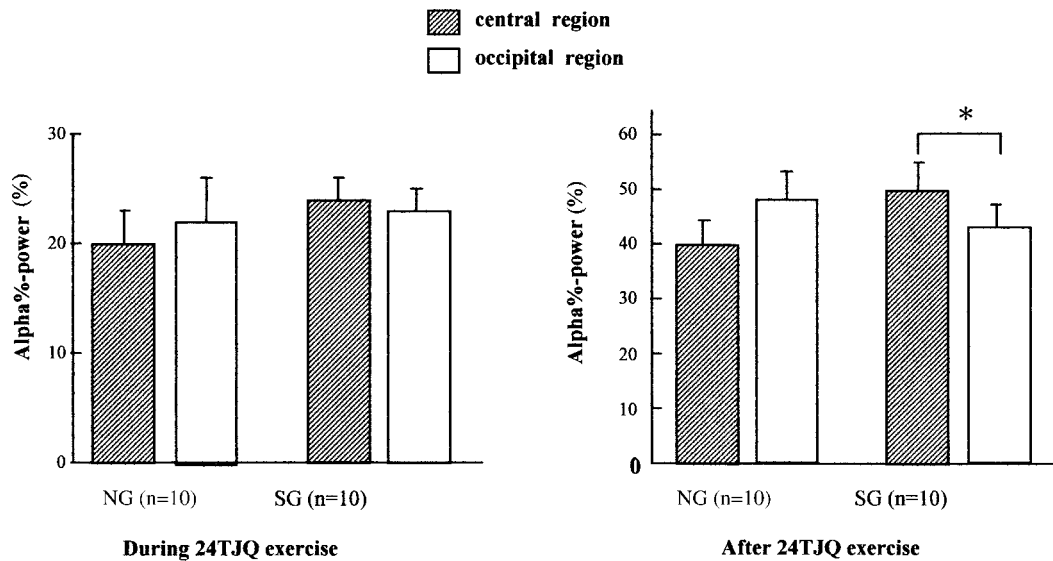


Fig. 3 Changes of alpha wave appearance rate in central and occipital regions during and after 24TJQ exercise for the novices' group and the skilled group. Values are mean  $\pm$  S.D. \* $p < 0.10$ . NG: novices' group; SG: skilled group.

et al., 1993), it usually needs expensive equipment that is difficult to be popularized in most areas. In such a case, besides its economy requiring no special equipment except postural changes, whether TJQ is beneficial to improve muscle strength or physical fitness is also a very interesting point. At the present study, we measured the physical fitness test in a skilled and a novices' group, the values from the skilled group were significantly greater in side step, sit-ups and standing trunk than those from the novice group. This conformed to the

results reported by Lan et al. (1998) that TJQ training could increase 15–20% strength of knee extensor/flexor, and by Wolfson (1996) that significant strength gains achieved by intensive training could be maintained by TJQ exercise.

Taking the waist as the movement center, TJQ requires practicing on a natural semi-squat posture, sometimes even standing on a single leg (Taijiquan exercise, 1983; Taijiquan total collection, 1990). These motion characteristics insistently exert a moderate workload on lower extremities and waist that

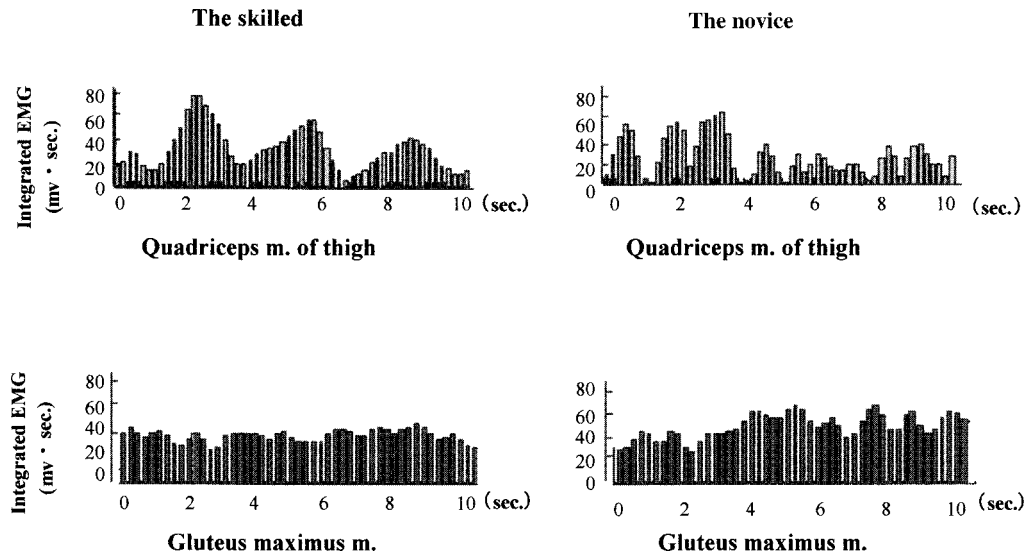


Fig. 4 The characteristics of integrated electromyography appearance on two cases from each group.

is helpful to enhance muscle strength of lower extremities or abdomen, and that is why the results from the skilled group showed greater values of side step and sit-ups. The better standing trunk flexion of the skilled group can be comprehended by many stretching-like components included in 24TJQ exercise. Lan (1996) also reported that TJQ group had better trunk flexibility in comparison with their sedentary counterparts. The above results suggest that 24TJQ is helpful to improve physical fitness including agility, flexibility and muscle strength or endurance ability.

The average intensity in the skilled group was greater than in the novice group. We supposed that this was associated with the motion characteristics of 24TJQ. Video record indicated that the skilled participants performed 24TJQ on a stable low posture or semi-squat posture while the novices on an unstable high posture. iEMG appearance strongly demonstrated this difference. The novices had not yet mastered the exercise very well; they often showed a sharp and unstable variation of iEMG. But the skilled participants have already mastered the exercise, they could control their motions skillfully by carrying out slow concentric or eccentric contraction of four extremities and much isotonic contraction of lumber-back muscles, so iEMG were mainly expressed as smooth and rhythmical normal distribution mountain form on quadriceps m. of thigh and stable “level” form on the gluteus maximum m.

The low center of body gravity or the semi-squat posture required a relatively greater muscle contraction that resulted in significant increase of surface temperature in the skilled after exercise. The different workloads in both groups were also testified by the different HR changes during exercise that the skilled showed significant greater HR than the beginners.

Gong et al. (1981) reported that the average HR in 24TJQ exercise for 48–80 years old subjects was 104 bpm, while Matsunami et al. (1998) mentioned that the HR change in 24TJQ exercise was between 83–110 bpm for the subjects of

averaged 61.3 years old with an averaged 7.4 years TJQ experience. In our study, the HR change was between 108–142 bpm and the average intensity were between 50–60%  $\dot{V}O_2\text{max}$ , which is equal to walking exercise on the speed of 75 m/min (Ueya, 1991) and lower than aerobic dance (Sato, 1997). This intensity is between 50–85%  $\dot{V}O_2\text{max}$  that is recommended as a safe and efficient exercise for healthy adults by ACSM concerning exercise prescription (American College of Sports Medicine Position Stand, 1990). Although the intensity of 24TJQ remains controversial due to the differences of subjects in age and experience time (Brown et al., 1989; Zhou et al., 1984), our study indicated that the average intensity in the novice group ( $49.3 \pm 10.1\%$   $\dot{V}O_2\text{max}$ ) was lower than in the skilled group ( $60.4 \pm 8.6\%$   $\dot{V}O_2\text{max}$ ) even though the average age showed the same ( $p > 0.05$ ). This result implicated that the intensity could be increased along with the increase of experience time or regulated by the change of motion style.

Out of the ordinary, the skilled group's RR was lower than the novice group's during exercise. Because the skilled participants have automated all the movements, they have enough capacity to apply the “shadow-boxing breath” by integrating their respiration rhythm (a kind of abdominal breathing) with the corresponding movements (Taijiquan total collection, 1990). That is, to inhale when bending the body or withdrawing four limbs and to exhale when stretching the body or moving four limbs forward. We supposed that this “shadow-boxing breath” resulted in fewer RR in the skilled participants than in the novices. Abdominal breathing is often applied as a mental training method for sports players to obtain relaxation effects before/during strained (stressful) sports contests, or to build up a state of harmony between mentality and body (Inomata, 1991). Given abdominal breathing, we supposed that a positive mentality training effect is also possible from 24TJQ practice.

As a psycho-physiological variable, EEG was used to check relaxation and concentration effects of 24TJQ exercise. By comparison with the alpha%-power to beta%-power, both groups showed high beta%-power during exercise and big increases of alpha%-power after exercise. This is basically consistent with other reports about the influence of exercise on alpha-beta wave (Petruzzello and Landers, 1994; Shibata et al., 1997). However, 24TJQ is viewed as a general exercise, we thought that mind concentration or heavy somatic awareness on body motions in 24TJQ exercise also contributed to inhibit alpha appearance or displayed an alpha-attenuation pattern, which resulted in high appearance of beta%-power instead.

Just as the other eastern conditioning exercises such as Zazen (oriental meditation) or Chinese Qigong (Kawano, 1994), the ultimate objective of TJQ is to reach a special spiritual world as if dissolving or integrating oneself into the universe (Taijiquan exercise, 1983; Taijiquan total collection, 1990). In the present study, the data from both groups revealed nearly the same values of alpha%-power during 24TJQ, but the skilled group's value was higher than the novice group's in both eye-closed rest/recovery period ( $p < 0.05$ ). The reason might be partly explained by that the skilled often applied deep self-consciousness during practice or exact somatic awareness on body motions that is recognized as a major criterion to evaluate the expertise of TJQ. This high cognitive state trained in the long years of practice has influenced the frequency appearance of EEG, and make the skilled obtain a quick/effective psychological relaxation effects.

Frequency of EEG is commonly regarded as the indicative of differences in general physiological and brain activation level. Lower EEG frequencies have been found to be associated with depression and fatigue while higher frequencies are associated with high excitation. The skilled have regularly undertaken the exercise, and have developed a certain emotional and/or physical dependence on this exercise behavior. This emotional change indirectly indicates that 24TJQ attracts strong interest among the skilled participants. We supposed that the higher beta%-power tendency in skilled group means that they might be possibly in a greater physiological excitation state even during rest. This assumption was supported by Jacobs' (1986) notion about dependency development and also comforted to the result reported by Helen et al. (1996) statement that high involvement of exercise will bring high frequency (beta) activity.

It is ordinary in normally psychological conditions that an occipital dominance of alpha wave appears (Okuma, 1991). Kawano (1990) and Sinakawa et al. (1992) demonstrated respectively that alpha wave would spread to the frontal head from the occipital head, or tend to appear simultaneously with the occipital one when a specialist in any field concentrates his mind deeply on his field of interest. In fact, our study also showed some very interesting results of alpha occipital dominance in the beginners and alpha central dominance change in the skilled group. Due to the deep concentration on body motions in the exercise, the skilled indicated alpha shift

tendency from occipital to central or frontal head. Because the dominant shift of alpha wave could be implicated as an effective factor to evaluate mind concentration degree (Kawano, 1990; Sinakawa et al., 1992), our results denote that 24TJQ could be recommended as a mental training method to upgrade mind concentration capacity in the field of sports.

In summary, our results demonstrate that 24TJQ is beneficial to keep or improve agility, flexibility and muscle strength or endurance ability in middle-aged women; it is an aerobic exercise with moderate exercise intensity that gives a special effect on the cardio-respiratory system. Furthermore, 24TJQ attracts strong interest among the skilled participants, some relaxation and mind concentration upgrade effects could be expected through long years' practice.

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