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Electrodermal activity of the skin assessed using Ryodoraku method after a single training session in taekwondo competitors

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Summary

Introduction. The diagnostic and therapeutic Ryodoraku method is based on the Traditional Chinese Medicine (TMC) and involves the measurement of electrodermal activity (EDA). 24 points are considered the representative points for the activity of various meridian pathways. The aim of the study was to assess the effect of a single training session on EDA change using Ryodoraku in taekwondo competitors and the analysis of the usefulness of such methods in training.

Material and methods. 18 taekwondo competitors aged 15-25 years participated in the experiment. The control group comprised 20 males, the students of the University of Physical Education aged 20-24 years. In both groups, the EDA measurement using Ryodoraku method was performed twice. In the taekwondo competitors the measurements of electroconductivity were performed before and after the training. In the control group the measurements were taken at a one-hour interval. For the statistical analysis the Shapiro-Wilk (SW) test, the Wilcoxon signed rank test and the Mann-Whitney-U test were used. The significance level was set at $p \leq 0.05$.

Results. Lower values were obtained in taekwondo competitors during the initial study, as compared to the control group. After the training a statistically significant increase in the mean values was noted in the experimental group. The results of EDA measurement obtained from the control group did not show any statistically significant differences in the comparative testing.

Conclusions. A signle training session results in the increase of electrodermal conductivity of the Ryodoraku representative measurement points (RMP) in taekwondo competitors. The obtained results may reflect post-exercise stimulation of the Autonomic Nervous System (ANS) sympathetic component.

Introduction

Taekwondo as a martial art, which in its traditional form, has maintained its specificity characteristic for eastern philosophy, despite being adapted to western conditions. This is practically the only significant difference between taekwondo and other disciplines known in the western culture. Despite the obvious individuality of taekwondo, the training process in this martial art is virtually governed by the same rules as the sport disciplines which are well known in western culture Contemporary training, especially if highly qualified, is rather burdensome for the competitors and the success depends not only on an adequately planned training, rest, a balanced diet, mental preparation as well as on prevention and effective treatment of contusions.

Sometimes, success or failure in sports results from the not completely understood fluctuations in the area of psychosomatic or volitional features of the competitor. A possibility to diagnose such conditions allows a deeper insight into the reasons of balance or disharmony of the competitor's performance on multiple levels of functioning [1,2].

During the past several decades, the sports medicine has developed highly in terms of technology involving advanced diagnostic approaches which contributed to the improvement in the effectiveness of prophylaxis and treatment of competitors. The development of sports psychology, in turn, added the element of mental work to the training to develop the self-esteem, improve concentration, remove psychical blockades or cope stress. However, increasingly, attempts are made to combine the approaches, introducing diagnostic and treatment methods from the field of the so called integrative medicine implying close cooperation between the official academic medicine and other methods. In sports, integrative medicine is focused on better understanding and interpretation of complex psychosomatic reactions of the competitor's body under conditions of substantial training load, especially before competitions. It is also aimed at better anticipation of all disturbances or homeostasis or body dysfunction in competitors. Methods of this kind are accepted only on condition that their effectiveness is not only assisted by therapeutic experience, but they can also be verified using empirical research approaches. These involve, first of all, combining conventional approaches with the experience in traditional systems of diagnostics and treatment as well as the methods of the so called alternative and complementary medicine. According to the National Center for Complementary and Alternative Medicine (NCCAM), the borderlines between the unconventional (complementary and alternative medicine – CAM) and conventional medicine boundaries are flexible and specific CAM practices may be generally accepted in the future [2,3,4].

Anyway, CAM still raises many emotions. Some environments ignore the fact that CAM exists. However, it does not change the fact that, e.g. as results from broad analyses, among 594 family doctors in the US, 44% declare that in case of some patients they would be ready to cooperate with CAM therapists. The survey from 2007, conducted by the National Health Fund showed that about 38% of the US adult population use CAM [5,6]. The scientific reports on taekwondo are mainly focused on the injury rate in this martial art [7,8,9, 10,11], analysis of taekwondo techniques [12], physiological aspects of training and competition [13,14], anthropological aspects [15] or the role of this martial art in the broadly understood issue of physical culture [16].

There are few reports on athletes using Cam approach. They mainly pertain to the application of acupuncture, chiropractic, reflexology, aromatherapy, treatment with herbs and antioxidants and body-mind therapy [17].

As for taekwondo practitioners, there are available reports on using chiropractic by this group of athletes. The reported study suggests that there is no direct access to the therapists using this form of treatment. The respondents also suggest that information about this form of treatment is sometimes wrong [18].

The study suggests that conventional treatment are most often aided by CAM which is connected with traditional methods of diagnostics and treatment. CAM is most often represented by Traditional Chinese Medicine (TCM). TCM implies that, apart from the commonly known in western medicine body systems, such as the circulatory or lymphatic system, there is the system of life energy, known as chi. According to the Chinese, this energy circulates in the body along 12 lines/channels called meridians. Conventional medicine is obviously far from accepting the viewpoint based on TCM, although it also sees the correlation between different body structures and functions. They result from the relation between the skin, the nervous system and the internal organs, developed at the embryonic stage and manifested by segmental reflexes of the spinal cord, viscero-dermal reflexes, the presence of Head's hyperalgesic zones and the Head-Mckenzie's so called points of maximal pain or trigger points located within these zones. Researchers, seeking the relationship between segments and meridians showed that the course of meridians, especially on the limbs is parallel to the course of sclerotomes, myotomes or dermatomes and most of the acupuncture points are located on the peripheries of dermatomes or within the reflex area of vegetative zones. According to the Chinese, all health-related problems are due to the disorders within this energy zone, manifested by the conditions of the so-called energy excess or deficit in each meridian [19].

Presently, a measuring equipment is used to diagnose the energy levels in meridians. One of the techniques of testing reactivity points on meridians is Ryodoraku, the Japanese diagnostic and therapeutic method developed by Youshio Nakatani in 1950. Ryodoraku literally means "the line of good conductivity" ("ryo" – good, "do" – conductivity, "raku" – line). This method allows to determine electric activity of each energy channel. Based on the results we can assess the activity of each internal organs, connected with these channels. Ryodoraku involves the measurement of dermal conductivity for direct (galvanic) current in 24 points on the body assumed to be representative for the activity of each meridian pathway (Representative Measuring Point – RMP). These points are characterised by electric conductivity equal to the mean value of the electric conductivity of all points on a given meridian (Fig. 1 and 2) [20].

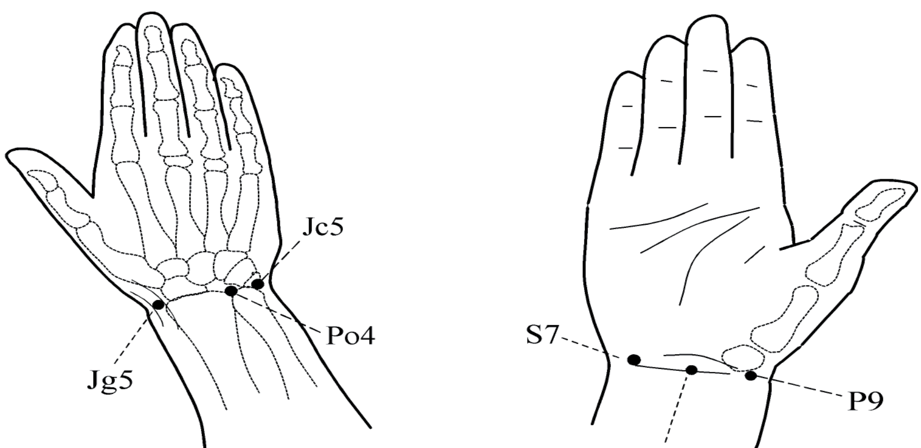

Fig. 1. Location of Ryodoraku representative measurement points on hands (Bohuń et al, 2003).

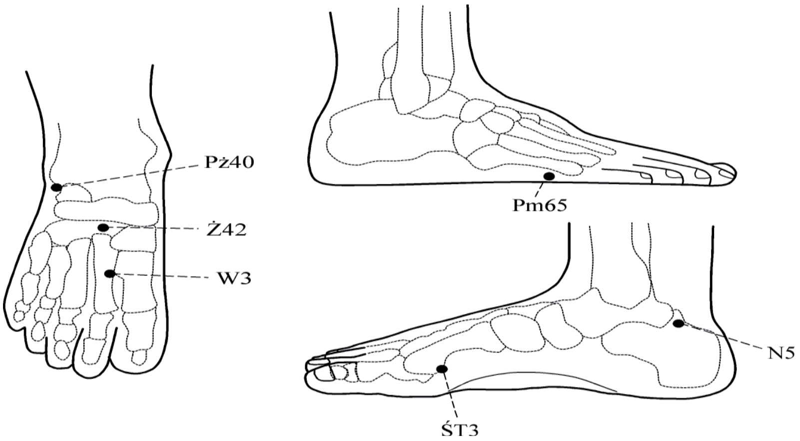

Fig. 2. Location of Ryodoraku representative measurement points on feet (Bohuń et al, 2003).

The goal of the presented study was to assess the effect of a single training session in taekwondo competitors on EDA changes using Ryodoraku method and to analyse the usefulness of this approach in training.

Material and methods

18 males aged od 15-25 years (the mean age 19 years) participated in the experiment. The experimental sample comprised taekwondo practitioners at different levels of advancement (ranks). All the subjects were competitors of the Taekwon-do Academy in Czestochowa. The sample included: 10 subjects training 5years, having the ranks from 10 Cup to5 Cup, 8 subjects training more than 5 years, having ranks from 5 Cup to I Dan. The study was carried out in the sub-period of special preparation for a competition. The control Ryodoraku measurement was performed in 20 male students of the University of Physical Education in Wroclaw aged 20-24 years (the mean age -22 years).

The measurement using Ryodoraku method was performed twice in the experimental group – prior to the training and about an hour after the training and twice in the control group, at one hour interval. The Kolmio Kiełkowscy device was used for the measurement. Prior to the measurement it was checked whether the skin was sweated and whether there were any visible damages in the RMP . The subjects with elevated body temperature (above 37°C), those with bacterial or viral infections or inflammatory conditions and acute injuries in distal segments of the upper and lower limbs were excluded from the study. The measurement of RMP points was performed each time in the afternoon hours in both groups, no sooner than 2 hours after the last meal in a sitting position in the rooms where ambient temperature was from 22 to 24°C. After finding the RMP, the measurement was taken. First, the electrodes were placed in the appropriate receptacles, the device was switched on and the "diagnoscope" was option selected. A speck of cotton wetted in saline solution was inserted in the active electrode cavelet. After preparing the subject for the measurement the device was calibrated by touching the passive electrode with the active one to obtain current flow of 200 mA. The sound signalizing the end of calibration informed the user that the device was ready to perform a measurement. Next the subject was given the passive electrode to hold it in the hand which was not tested. Next, the electrode was placed on each RMP in the following sequence: the left arm, the right arm, the left foot and the right foot. During the measurement the electrode was placed perpendicular to the skin surface with a slight, even pressure. The measurement of symmetric points was performed at the following meridians: lungs (H1), pericardium(H2), heart (H3), small intestine (H4), triple warmer (H5), large intestine (H6), spleen-pancreas (F1), liver (F2), kidney (F3), urinary bladder (F4), gallbladder (F5) and stomach (F6) [20]. To study the normality of distribution of the analysed parameters the Shapiro-Wilk test was used. As most of the variables did not meet the normal distribution criterion, the nonparametric tests were used for further distribution. In order to determine the significance of the between subject differences, the Wilcoxon signed rank test was used while for determining the between group differences the Mann-Whitney U test was used. The differences were considered statistically significant at $p \leq 0.05$. The calculations were made using Statsoft Statistica program ver. 10.0.

Results

The mean values of meridian point electroconductivity obtained from both groups were subjected to statistical analysis. The following points were considered for the analysis: H1 to H6 on the hand and F1 do F6 on the foot as well as the measurement results obtained from the right and left side of the body, separately and in the experimental group. The values obtained from the initial measurement were significantly higher ($p=0.000008$) in the control group (Tab.1). In the experimental group a statistically significant increase ($p=0.0007$) in electroconductivity was observed, however, the results were still lower as compared with these of the control group ($p=0.002$). The measurement of electroconductivity in the control group did not show any statistically significant differences.

Table 1. Comparison of the mean values of electroconductivity in all the representative measurement points in the study and control group mean±SD; *p≤0.05

	Initial measurement	Final measurement	Wilcoxon test
Experimental group N=18	23,1±13,1	42,5±20,3	p=0,0007*
Control group N=20	74,1±34,2	74,3±33,8	p=0,8
Mann-Whitney U test	p=0,000008*	p=0,002*	

Table 2. A comparison of average values of electroconductivity at the measuring points on the hands and feet, before and after training in the experimental group, mean ±SD, * p ≤ 0.05

	Measurement before the training	Measurement after the training	Wilcoxon test
Points on hands (H1-H6)	19,16±14,2	42,11±26,1	p=0,003*
Points on feet (F1-F6)	27,04±16,0	42,94±17,4	p=0,0005*

Table 3. A comparison of average values of electroconductivity at the measuring points on the left and right side of the body, before and after training in the experimental group, mean ± sd, * p ≤ 0.05

	Measurement before the training	Measurement after the training	Wilcoxon test
Points on the left hand (H1-H6)	20,23±14,7	39,67±23,9	p=0,004*
Points on the right hand (H1-H6)	18,09±14,2	44,55±29,9	p=0,002*
Points on the left foot (F1-F6)	25,81±14,7	40,54±16,7	p=0,001*
Points on the right foot (F1-F6)	28,29±17,8	45,35±19,3	p=0,0006*

The mean values obtained from the measurements of the points located on the hands and feet in the experimental group indicate the increase in values after the training (Tab. 2) which is more pronounced in the case of hands. Only in the F4 point (urinary bladder) the increase was statistically insignificant (before – 14.05; after – 25). Also after the training the differences between the mean values obtained from the feet and these obtained from the hands were significantly smaller.

The comparison of the mean values obtained for the points located on hands and feet at the left and right side of the body indicate a higher excitation at the right side (Tab. 3). In the case of H1 point (heart meridian) the differences between the mean values obtained from the left and right hand were significantly smaller (before: p= 0.073, after: p=0.073)

Discussion

The Ryodoraku method originating from Traditional Chinese Medicine (TMC) is based on measurements of electrodermal activity (EDA) which are also popular in western medicine with the only difference – the choice of RMPs on the skin and interpretation of the results in Ryodoraku are based on the TMC rhetoric and experience. EDA is generally believed to be an exceptionally sensitive index reflecting electric phenomena generated by the skin and measured on skin surface. Due to the sensitivity of this index, the fluctuations in EDA results are defined by researchers as a certain kind of electric lability of the human body. The latter is, in fact, a biological system subject to continuous fluctuations. This allows to observe its dynamics and the ways the body reacts to subtle impacts. When the body is not subject to significant amplitude fluctuations and the changes in the stimulus are not too abrupt, all these fluctuations and changes can be successfully compensated by the rearrangement of internal regulatory resources. The awareness that such mechanisms exist seems necessary in the analysis of the study results presented in this paper. It also implies such an attitude to EDA measurements which allows easier acceptance of the problems connected with the results of the study on EDA signal. This, in turn, allows to avoid overinterpretation of the obtained results.

Actually, the reported experiment reflects a highly sensitive transient state of bioelectrical reactivity of the skin in taekwondo competitors, observed during a single training session as compared to the control group, not exposed to such a stimulation. The available papers reporting differentiated EDA signal changes after body exposure to e.g. acoustic waves of low intensity are good examples confirming the extreme sensitivity of the human body to such subtle stimuli [21]. The authors dealing with the analysis of the problems experienced by the individuals who are hypersensitive to electromagnetic stimuli emphasise subtle differences in heart rate (HR) and electrodermal activity of the skin [22].

Obviously, the sensitivity and variability of EDA measurement is not necessarily associated with its unreliability or does not have to be rejected as the useless approach from the perspective of training tasks. From the point of view of a coach, each training unit is equally important as the final super-compensatory effect is built based on it. This is also true in case of the observation of isolated bioelectric signals. In a longer perspective, they can aid the process of adequate dozing of training tools which guarantees the desired retuning of the body in response to a given training stimulus.

The approach could be used for diagnosing the conditions leading to overtraining. Wu et.al observed EDA values measured using Ryodoraku method in the subjects undergoing a 6-week training on a treadmill. The results indicated elevated levels of EDA in the training subjects compared with the control group.

This effect was not sustained and after 3 months of the exercise program it was observed that skin conductance returned to the baseline level [23]. This study also showed a statistically significant stimulation of dermal bioelectrical activity after a single training session in the group of taekwondo practitioners. However, the difference in mean EDA values between taekwondo practitioners and the control group obtained from the baseline study is puzzling. In the scientific literature, the differences in EDA depending e.g. on personality type, mood or the volitional features revealed in the subject during the measurement as well as on the subject's general psychophysical condition, the level of stress or the quality of sleep. The time of the day when EDA measurements are taken is also important. This factor was considered in the reported study and all the measurements were taken in the afternoon hours, however, no sooner than 2 hours after a big meal. In scientific literature there are available reports on the analyses of EDA signal monitoring in a 24-hour cycle during everyday activity performance. These studies reflect how the life functions and activities are synchronised in response to differentiated stimuli present in a 24-hour cycle [24,25].

According to researchers, the changes in EDA signal reflect the state of autonomic nervous system (ANS). EDA elevation shown in this study after a single training session may indicate stimulation of the ANS sympathetic component. The sympathetic activity is known to increase due to physical exercise or stress.

The sympathetic system is responsible for general activity of the body. It accelerates cardiac activity and respiratory functions, dilates blood vessels thus elevating blood pressure and under stress it stimulates emotional tension which, in turn, stimulates the body for action. The above mentioned baseline EDA value, which was lower in the training subjects compared to the control group, might have indicated a higher parasympathetic dominance in this group. There is no doubt, however, that without prospective comparative studies or EDA analysis in the remaining periods of the training cycle it is difficult to assess the probability of a real correlation between these results and post-training adaptive changes. Interestingly, the results of this study revealed big differences between the mean values obtained from the hands and feet before the training and reduction of these differences after the training. This is indicative of a harmonising and modulating effect of physical exercise. In the analyses of study results using Ryodoraku method the asymmetry between the upper and lower body and, more exactly, upper versus lower limbs is of note. This phenomenon is interpreted in Ryodoraku nomenclature as disharmony of energy. Such a disharmony may result from general body fatigue states, the feeling of life energy loss, a higher susceptibility to stress, neuroses and even some mental diseases. The asymmetry between the upper and lower body can manifest by lower values (decrease) at the points located on the hands and higher values (increase) at the points located on the feet or vice versa. Such a quick regaining of balance between the upper and lower body after a single training session seems quite surprising, although it is worth noting that the study was carried out during the special preparatory stage when the competitors attained their peak form and this factor may have been somehow responsible for the compensation [26,27,28,29].

In spite of some objective difficulties in EDA analysis, this measurement was many times used for diagnostic purposes or for the evaluation of treatment effects in such fields as psychopathology, neurology, physical therapy or dermatology [30, 31,32,33,34,35,36,37].

Żytkowski used EDA based on Ryodoraku method to study the patients with sacrolumbar spine pain syndromes. The patients were subjected to physical therapy and acupuncture [38]. Ryodoraku was also used for the assessment of laser acupuncture treatment and rubber cupping [39]. Su et al. compared the effect of different kinds of office light on the mental sphere and their results were similar to these obtained using Ryodoraku based EDA measurement [40]. Other authors assessed the diagnostic value of Ryodoraku in subclinical hypothyroidism [41] and renal colic[42] while Lin et al. studied the effectiveness of infrared treatment in dialysed patients [43]. There are also available reports on the analyses of changes in Ryodoraku record, depending on BMI [44]. The effect of traditional Chinese Qigong exercise performed at different times of the day on EDA measured using Ryodoraku method was studied as well. The stimulating effect of exercise was more pronounced during afternoon hours [45].

In the presented study the training was held in the afternoon hours and this may be the reason of such a pronounced increase in EDA in taekwondo competitors and the substantial increase in the values obtained from the hands and feet. The only exception was the F4 point on the right foot, responsible for the urinary bladder. The mean values obtained from this point were statistically insignificant in the comparative study. According to the table of Ryodoraku symptoms [20], the lower electric conductivity of this meridian may result, inter alia, from the stiffness of muscles of the nape of the neck, heaviness and weakness of limbs, dull pain or sciatica. The result obtained from F4 point in this study may be due to the way taekwondo training is carried out. The athletes train without shoes and the feet are in direct contact with the floor. There is a probability that F4 point located on the outer edge of the foot, medially and lower than the head of V metatarsal bone, might have been many times stimulated during the training. Other authors suggest, based on their experience. that in acute or short-lasting conditions, intensive stimulation is characterised by elevated EDA levels (according to Ryodoraku nomenclature this is the state of energy excess). Chronic conditions or multiple excess stimulation is in turn associated with the tendency to reactivity reduction (energy deficit). However, the tendency to energy deficit in F4 point requires further analysis. It is essential to find some characteristic traits in taekwondo practitioners' foot constitution, especially the layout of fulcrums or the presence of calluses in the RMPs. Moreover, the kind of body lateralization should be determined in the subjects, especially that, as mentioned above, the decreased reactivity to a training stimulus in F4 point was found only on one (right) foot.

The comparison of the mean values obtained from the EDA measurements at the points located on right and left hands and feet indicated a higher excitation of the right side of the body. In the H3 point (heart meridian) the mean values of electroconductivity were made up for in the right and left hand which was indicative of the so called energy excess. According to the table of Ryodoraku symptoms, energy excess in this meridian may be connected with such symptoms as pain in the nape of the neck, heavy limbs, throat dryness and cardiac activity disorders. Since the training was intense and mainly the upper body was exercised, the above mentioned symptoms are confirmed. The slight differences between body sides may be also connected with lateralization. With substantial differences in Ryodoraku assessment, possible dysfunctions or internal organ disorders, the disturbances of superficial vegetative nerves and impairment of a given half of the body are indicated [28,29,37].

Conclusions

1. A single training session in taekwondo results in the changes in electrodermal conductivity assessed using Ryodoraku method.
2. The type of these changes is connected with the increased electrodermal conductivity at Ryodoraku representative measurement points.
3. The increased electroconductivity revealed in this study after taekwondo training may indicate the post-exercise stimulation of ANS sympathetic component.

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