Cardiovascular signs of training adaptation in combat sportsmen and martial artists and Chen-style Taiji Quan's further effects on health

Thesis booklet

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1. Introduction

The life expectancy at birth in Hungary was 74 years in 2009. For this life-span it's practically needed to keep healthy. Health-consciousness is needed for that, including good stress-management, healthy nourishment, and regular physical activity.

As in other developed countries, the cardiovascular diseases give the half of total mortality in Hungary. The second is the group of tumours (25% of total mortality). Free radicals have proved rules in carcinogenesis, and antioxidants are often used in prevention and treatment of tumours for defend the adverse effects of free radicals.

Preventive effects of physical activity are eg. that the hazards of development of coronary artery disease, heart attack and stroke diminish, blood pressure decreases, it protects against obesity, and the development and progression of musculoskeletal diseases also decrease with physical activity and its intensity. Although sport activity increases the free radicals' level in the organism acutely, in long-term it stimulates the total antioxidant capacity, improves its function, in this way it can contribute to the longer and healthier life.

Combat sports appeared in Hungary first in 1875, with box-teaching within the frame of Hungarian Athletic Club. In the 20th century, in the twenties-thirties, fencing, wrestling and judo also showed up. After several decades, following the presenting of judo in the Olympic Games in Tokyo in 1964, and also the partial traversability of country boards, martial arts also appeared in Hungary. There were and still are many Hungarian success in the classic combat sports. Nowadays, there are about 150-180 thousands who practice martial arts in the country, and they have competitions regularly. However, there are just a few comprehensive studies about the cardiovascular training-adaptive signs of combat sportsmen, and there is no one about those of martial artists.

Taiji Quan is also a Chinese martial art. The Chinese communist regime prohibited the open-air practice of martial arts. Therefore the fighting elements of Taiji Quan had been cut off, and today, world-spread Taiji Quan is known as a health-promoting movement. The first style of Taiji Quan was Chen, the Yang, the thwo Wu-type, Sun and Wudang –styles developed from it. Chen-style is the only one which preserves the fighting elements. Until now, only one study happened among Chen-style Taiji Quan practitioners. Approximately 1000 articles have been published about the Yang-, Wu- and Sun-style Taiji Quans' effects on physical and mental health, but those effects which we aimed to study, none of them investigated.

2. Aims

2.1. Cardiovascular training-adaptive signs of combat sportsmen and martial artists

Power sportsmen are generally investigated together, independently of dominant element of the sport activity (static – weight-lifers, body builders, power lifters; dynamic – martial artists, boxers; static & dynamic – wrestlers, judoists. The results were not so misleading until only wrestlers and judoists were merged with static power athletes, but martial arts contains absolutely different movements. It is true that these sports also need static power, but they use even more dynamic element, in their leg, arm and body work as well. Therefore combat sportsmen's cardiovascular training signs differ from those of static power athletes. Thus, our aim was to recommend a new ranking of combat sportsmen and martial artists to sports physiologists. Another goal was to get know the special training signs of this group of sport activities, their effects on blood pressure, and on the cardiac morphological, functional and regulatory signs. We tried to get the picture about how in these sports the amount and rates of endurance, dynamic, impulsive and static works affect the cardiovascular system, on the base of echocardiological results and arterial stiffness (the arteries' becoming inflexible). We also aimed to compare the results of the different kinds of martial artists and combat sportsmen.

2.2. Chen-style Taiji Quan's further effects on health

2.2.1. Chen-style Taiji Quan's effects on resting heart rate variability and heart rate changes during exercise

We made further studies on Chen-style Taiji Quan practitioners. We wondered how long-term Taiji practice and the personalized recommendations on life-style and training methods – if somebody's results differ from the normal range – influence the heart rate variability (HRV) parameters. We aimed to measure the HRV values at rest before Taiji training session, and the exercise's effects on heart rate changes. One month later we repeated the measurements. We supposed the results of those who needed some life-style and practical advice after the first measurement, to be better after the consultation for the second time. In order to clarify the degree of the load, we completed our studies with antropometric measurements.

2.2.2. Effects of Taiji Quan practice on total antioxidant capacity

While in the East, for thousands years, the large quantity of Qi (energy, power) and its streamline have been believed to be the basic of health, in the nineties in the U.S.A. after the more and more successful researches the most famous antioxidant researchers declared that the higher one's antioxidant-level, the healthier the person is.

Plasma carotenoid level shows the strongest correlation with the total antioxidant capacity of the blood, and the concentrations of carotenoids in the blood and in the skin also correlate.

Hereby the skin carotenoid level can give indirect information about the total antioxidant capacity of the body.

We searched the answer for the question: if Traditional Chinese Medicine regards Taiji as augmenting the quantity of Qi in the body, whether practitioners have really higher antioxidant levels measured by the Biophotonic Scanner than control persons?

The measurements were intended to perform in the training camp of the Hungarian Chen-style Xin Yi Hun Yuan Taiji-Quan Association in the summer of 2009. We aimed to follow the skin carotenoid level through the trainings of the practitioners by 3 measurements (on the 1^{st}, 3^{rd} and 5^{th} days) through the camp with the Biophotonic Scanner of Pharmanex Company. Beside the measurements we also meant to make an interview with the participants about all the factors which can modify the antioxidant level.

We also intended to measure the carotenoid-level of a reference group with a resting measurement, completed with the interview.

Our questions were the follows:

1. Whether Taiji practitioners' SCS values are higher than those of the reference group?
2. Whether the Taiji training camp has SCS value-increasing effect?
3. Whether is it really due to Taiji Quan practice if the practitioners SCS scores are higher than those of reference people?

The practitioners' results we wanted to compare with other studies's results which were designed to check antioxidant levels of other groups of sportsmen with the same device.

2.2.3. Taiji Quan's psychological effects

We investigated the following questions:

1. Can Taiji practice make better the mental health?
2. Does Taiji practice have any effect on trait anxiety and arousability?
3. Is there any personality traits and/or coping mechanisms which is special for Taiji practitioners?
4. Is there any component of psychological immune competence which is typical in Taiji practitioners or which is improved by Taiji practice?
5. Does Taiji add something to the already known psychological gender differences?
6. Does more practice produce more particular traits?
7. Do capital practitioners differ from practitioners of the countryside in any psychological traits?
8. Does educational level have any effect on the results?
9. How do Taiji practitioners relate to other athletes of other sports?

3. Methods

3.1. Cardiovascular training-adaptive signs of combat sportsmen and martial artists

The resting blood pressure data of a large number (3767) of young men (2296 males) and women (1471 females) (age: 19-40 yrs) who participated in sports medical examinations were compared according to their sports. Athletes were arranged into definite subgroups based on their different sport activities, if their movement patterns characteristics were similar and if no significant intergroup differences were seen in blood pressures values. Cyclists and kayak-canoe and rowing competitors were grouped separately, as well as dynamic and static power athletes. Based on our previous studies, and because their blood pressure values also differed, athletes of dry-land and water sports were also detached.

Measurements were made by Omszöv Medic OM-362 mercury tensiometer, systolic (SBP) and diastolic blood pressure (DBP) values were evaluated separately in the analysis.

Echocardiographic investigations were made by a Dornier AI 4800 type device by a 2.5 MHz transducer, always at rest in the morning hours. 1051, 18-35 year-old males participated in this study. Interventricular septum thickness (IVSTd), left ventricular (LV) posterior wall thickness (LVPWTd), the internal diameter (LVIDd) and the left atrial diameter (LAD) were detected in 2D-guided M-mode parasternal depictions. End-diastolic LV wall thickness (LVWTd=IVSTd+LVPWTd), the total LV diameter (TEDD=LVWTd+LVIDd), and also the muscle mass were calculated: and LVMM= $(TEDD^3\text{-}EDV)*1.053$, where EDV is the LV end diastolic volume ($LVIDd^3$) and 1.053 is the specific gravity of the cardiac muscle. Muscular quotient (MQ) is the ratio LVWTd/ LVIDd. Cardiac measures were referred to the body surface area by fractions in which the exponents of the numerator and denominator are identical.

LV filling was determined by the ratio of the peak velocity measured during the early and late phase (E/A). The transaortal systolic peak velocity (AOV) was also measured.

Arterial stiffness was determined by TensioMed Arteriograph. The distance of jugulum (J) and symphysis (S) was measured by metal measuring tape, to get the distance of the root of the aorta and the bifurcation. The pulse wave velocity (PWV) was determined by the following:

PWV= J-S distance/transit time (the transit time is the time of PWV to get from the aortic root to the bifurcation, the half of the time between the detected first and second pulse wave)

The augmentation index (AIx) was calculated from the two systolic wave-peaks of the arterial pulse wave, from the difference of the amplitudes of the early, direct systolic wave (produced by the ejection) (P1) and second, reflected (late systolic) wave (P2), in the percentage of the pulse pressure (PP=SBP-DBP).

AIx=(P1-P2)/PP*100

The device gives also the value of the corrected augmentation index value to 80 beats/min heart rate (AIx80) which values we used further on. These measurements took approx. 15 minutes per person.

The results of the highest groups of combat sportmen and martial artists (judo, karate, kung fu, taiji, thai box) were compared again, with each other and with controls.

3.2. Chen-style Taiji Quan's further effects on health

All the studies of Taiji Quan practitioners were made among the members of the Hungarian Chen-style Xin Yi Hun Yuan Tai Ji-Quan Association.

3.2.1. Chen-style Taiji Quan's effects on resting heart rate variability and heart rate changes during exercise

From the advanced practicing group 10 males and 5 females tackled the participation.

Participants should have arrived earlier to the training session, and as calmly as possible (the sessions started at 6.30 p.m.). All the participants were healthy at the time of the study, only one young woman had ventricular extrasystoles (VES). She was involved the study because of the low number of female participants.

We measured HRV for 3 minutes at practitioners before the training session, in recumbent position, with Polar Vantage NV belt and watch. During the exercise, we used Team Polar belts. The parameters which we used later for evaluation were: heart rate at rest, pNN50, LF/HF ratio, Index stda, Index stdb, minimal, maximal and average heart rate during the exercise and their standard deviations. The parts of the training sessions were the follows: 30 minutes warm-up – Qi Gong (energy-developing exercises, 5 min), stretching (5 min), kicks, punches and jumps (15 min), stimulation of acupoints (the points which are used in acupuncture and acupressure therapies, 5 min), 26 minutes practice of form (traditional 83-step form), 34 pushing hands.

For being comparable with other studies, we also evaluated the results which were measured during only the form. After the first study and the evaluation of the data we had consultation with the participants, for those whose results were outlier of the normal ranges we gave personalized suggestions in the matter of training methods and life-style. One month later we repeated the measurements.

The antropometric techniques followed Conrad's methods. This method presents the slenderness of the body between the pycnomorph and leptomorph extremities, the robustness of the bone and muscular system between hypoplastic and hyperplastic extremities. To assess

the bone and muscle mass Drinkwater and Ross' body weight fractional method was used. Absolute values were expressed as a percentage of body weight. Relative fat content of the body was estimated on the basis of Parízková's algorythm, using the skinfolds. Lean body mass (LBM) and body mass index (BMI) were also calculated.

3.2.2. Effects of Taiji Quan practice on total antioxidant capacity

The measurements were performed in the training camp of the Association in the summer of 2009. The camp lasted for 6 days; we followed fifty practitioners' skin carotenoid level through the trainings (25 men and 25 women). The Biophotonic Scanner of Pharmanex Company was used; measurements were made on the 1st, 3rd and 5th days. The device is a Raman spectrograph, it emits blue laser-light (471,3 nm and 473,0 nm) on the skin, and when it hits a carotenoid molecule in the palm of the hand, the carotenoids reflect back green light at 507.8 nm and 509.8 nm, The quantity of the carotenoids can be calculated from the amount of the reflected light. The carotenoid level is defined in Skin Carotenoid Scores (SCS), 1000 SCS is the equivalent of 0.04μg carotenoids in 1 ml of blood plasma. Subjects had to put a defined point of their palm before the laser light. One measure lasted for 3 minutes. During the measurements we made also the interviews with the participants about their nutritional, drinking, sleeping, and dietary supplement eating habits, also about their satisfaction with their health status, actual work and private life. The participation was voluntary.

Practitioners trained 5 hours/day in the camp, which was altogether almost fivefold of their habitual weekly training time.

The results were examined not only of the whole group, but by subgroups according to gender, age (below and over 35 yrs), Taiji sport age (more or less than 5 yrs), weekly training time (more or less than 5.5hrs/wk), educational level (university or lower level), nutritional habits (vegetarian or meateaters).

After the camp a reference group (15 persons) was also investigated, only a resting measurement happened with the interview.

3.2.3. Taiji Quan's psychological effects

After informed consent, 73 volunteers (33 males, 40 females) of the 210 Hungarian Chen-style Taiji Quan practitioners participated in the investigation. 43 were inhabitants of the capital, 30 were rural; 31 trained less, 42 more than six hours/week, 35 had graduate of a university, 38 had lower qualification. Their mean age was 37.0±8.4 yrs, their sport age in Taiji was: 0.5-10 yrs (3.1±2.1).

Taiji Quan practitioners filled in five psychological tests. Results were compared according to their gender, educational level (academic qualifications and lower educated persons) and training time (at least or less than 6 hrs/wk) and residence (capital or countryside).

Tests

Beside a demographical questionnaire (age, gender, Taiji age, training time/week, residence and profession), participants completed the following psychological tests:

Goldberg's General Health Questionnaire (GHQ-60, Goldberg, Hungarian translation: Karczag) – gives a picture of one's instantaneous psychological status. Over 12 points it signs psychological distress, lower scores means healthy mental status.

Anxiety Arousability Inventory (AAI, El-Zahhar, Hungarian version: El-Zahhar, Sipos) – shows the degree of one's trait anxiety and trait arousability.

Athletic Coping Skills Inventory (ACSI-28/2, later it'll be mentioned as ACSI-28, Smith et al.) – for assessing sport-related coping skills; translated for Hungarian language by Sipos, Horváth and Jelinek.

Psychological Immune Competence Inventory (PICI) – an original Hungarian test designed by Oláh; reveals the development and efficacy of psychological immunity, capabilities to cope with stress, adaptation to environmental challenges and balance between these and own personality functioning.

California Psychological Inventory (CPI, Gough, Hungarian version: CPI-300 or S-CPI, Oláh), used to observe personality factors (interpersonal/internal values, intellectual efficiency, functional modes). Its scales are standardized; T-scores are used for evaluating one's social living level (mean = 50, S.D.=10).

Cronbach alpha values for inventories were in the range of -.606 (S-CPI, Psychological sense) to .94 (GHQ).

3.3. Applied statistics

All the statistical calculations were performed with STATISTICA 8.0 for Windows software (StatSoft, Inc., Tulsa, OK).

For the blood pressure, echocardiographic and arteriographic values, first we made one-way analysis of variance; later, post hoc Tukey tests for unequal numbers to reveal the differences among the groups. In some cases t-test for independent samples.

The heart rate variability and heart rate changes were evaluated with correaltion analysis; we also used POLAR Precision Performance 2.0 and SW program for the detailed informations.

For the skin carotenoid level-determination one sample t Test, Mann-Whitney U Test and Spearman Rank correlation were used.

For the psychological results, reliability tests and Factorial Analyses of Variance were applied for checking the four factors' grouping effects, and also for supervising interactions; and Univariate Analyses of Variance, and Tukey Honest Significant Difference for unequal numbers post-hoc tests for comparing the groups. GHQ scores showed non-normal distribution, therefore Mann-Whitney U-test was applied for these results, and its median with minimum and maximum values, and also quartiles will be presented. For the evaluation of the effects of the total training time (years and hours), we used sampling with replacement, forming always two groups, and calculated with t-tests for independent samples.

4. Results

4.1. Cardiovascular training-adaptive signs of combat sportsmen and martial artists

While male static power athletes' SBP values were the highest, together with those of cyclists and kayak-canoe rowing competitors, combat sportsmen SBPs were much lower (134.3±1.8 vs. 123.4±1.0 Hgmm, p<.001).

The ranking was similar in DBP values. Tukey tests didn't show difference, but with the t-test, the two power athlete-group differed (78.2±9.0 vs. 81.9±14.5 Hgmm, p<.05).

Woman had lower blood pressure than man's, this gender difference was larger in the systolic values. The males' SBP values were int he range of 117.6-137.1 Hgmm, while women's values were only 111.5– 119.9 Hgmm. Men's DBP were 74.5-85.4 Hgmm, females had 70.9-84.2 Hgmm. Among females, the intergroup differences were also smaller, with much less significant differences. Despite, the static and dynamic power athletes' results noticeably differed, although the differences were not significant (systolic values 114.3±12.8 vs. 117.5±10.0 Hgmm, p<.2, diastolic values: 72.2±7.5 vs. 73.9±8.6 Hgmm, p<.31).

Although each group of sports had lower heart rate than the control group, combat sportsmen had significantly lower heart rate than static power athletes (59.5±9.9 vs. 65.7±10.5, p<.01). Among the morphological training signs relative left atrial diameter was larger in combat sportsmen than in every other kinds of athletes (24.5±5.0 vs. 21.8±2.2, p<.01). Endurance athletes' relative left ventricular internal diameter was the largest and differed from both power athletes' group (37.7±2.7 vs. static power athletes 36.3±2.6, p<.05, dynamic power athletes 35.7±2.5, p<.001), but the two power sportsmen's group did not differ from each other significantly. Both power athletes' group's muscular quotient and relative left ventricular wall thickness differed only from those of controls and moderately active athletes. It was also the group of endurance athletes who had the largest left ventricular muscle mass (96.9±18.2) and it was larger than that of combat sportsmen (83.2±12.7, p<.001) and static power athletes (87.2±16.2, p<.01). Only controls' E/A ratio differed from combat sportsmen's E/A values. The LVET/QT ratios in all sports groups were lower than those of controls, except the values of the artistic athletes. The VCF values in static power athletes and leisure-time sportsmen were similar to controls' results, while the combat sportsmen results significantly differed from the results of static power athletes (1.2±0.2 vs. 1.3±0.2, p<.05). The groups did not show diversity in transaortic peak velocities (AOV), pulse wave velocities and augmentation indices.

Most of the variables of martial artists resembled to each other, but more martial artists' group differed from controls in heart rate, relative left atrial internal diameter, relative left ventricular wall thickness and muscle mass, and in muscular quotient and AOV. Thai boxers' muscular quotient and relative left ventricular muscle mass was larger than those of kung fu men (LVWT: 15.2±1.6 vs. 13.7±1.0, p<.05; MQ: 44.4±6.5 vs. 38.4±3.4, p<.05). Judoists' transaortic peak velocity was the largest (1.2±0.2), larger than that of Taiji practitioners (0.9±.01, p<.001), controls (1.0±0.2, p<.01) and thai boxers (1.0±0.2, p<.05). In E/A ratio,

AOV and AIx80 Taiji practitioners lagged behind the other martial artists' groups. Kung fu men had better arterial stiffness indices than thai boxers (AIx80: -75.8±14.8 vs. -57.2±9.0, PWV: 6.0±0.7 vs. 6.8±0.8, in both cases: $p<.05$), taiji and thai-box practitioners' AIx80 and PWV values were, although not in every case significantly, but worse than the others'.

4.2. Chen-style Taiji Quan's further effects on health

4.2.1. Chen-style Taiji Quan's effects on resting heart rate variability and heart rate changes during exercise

Results of the first measurement

For the first time 13 persons had nornal heart rate (60-80 beats/min), one person had higher, one had lower values. The pNN50 value was over 10% at 8 practitioners, one had 9.9%, one had 7.8%, 5 practitioners had lower values. The LF/HF ratio was around 100% at 6 of them, two of them had very low level (24.3% and 14.4%), the rest 7 persons had higher than 100%. The Index stda and Index stdb values of one practitioner – the mentioned woman's with VES – were very high (262.8 ms ans 231.2 ms), one had a little bit low values (38.1 ms and 11.5 ms), and one had only low Index stdb (9.8 ms). All the others had similar values as the elite athletes.

During the first session we found 76-149 beats/min heart rates, the average heart rate was 108±13 beats/min. During only the form the average heart rate was 111±11 beats/min, (83-128 beats/min).

After having evaluated the results of the first measurement, we consulted the participants, in case of very high LF/HF ratio and/or too low pNN50 values we proposed to the practitioners to release the level of stress in their life and do moderate trainings, and to those whose values were in the optimal range we suggested similar or a little bit more powerful trainings henceforward.

Results of the second measurement

For the second time, 4 persons showed bradycardia (46-59 beats/min) at rest, one had higher than normal heart rate (96 beats/min), the heart rate of the rest of the practitioners were in the normal range. The pNN50 values were over 10% in only 7 persons for the second time, but three others had almost good values, too (8.6-9.0%). Two practitioners had very low values again (around 0.0%). The LF/HF ratio was around 100% at 7 persons, only one had very low and one had very high values; although the rest of them had not normal values, but as their levels are frequent in the average population, we considered them as acceptable values.

The heart rate changes measured during the second training session showed slighty more moderate training than the first time one month earlier, the heart rate range was 74-141 beats/

min, the average heart rate was 103±13 beats/min. Taking into consideration only the work during the form, practitioners' average heart rate was 107±11 beats/min (85-130 beats/min).

Gender differences

We found significant differences between male and female practitioners in the intensity of exercise (mean heart rate), men had higher values. There were also differences between the gender groups in the minimal heart rate during the whole session and also during only the form for the first measurement. Men's average minimal heart rate for the whole session was 80±12 beats/min, women's had 68±5 beats/min ($p<.05$), during only the form the minimal heart rate values were 89±14 beats/min for males, and 73±10 beats/min for females ($p<.05$).

Correlations between the resting values and heart rate changes measured during exercise

- the average RR-intervals (and heart rate) at rest correlated with the average heart rate measured during the form ($r_{RR\text{-}int.}=-.43$, $r_{HR}=.51$);
- the standard deviation at rest correlated with the standard devation of heart rates measured during the whole session ($r=.54$);
- Index stda, Index stdb, pNN50 measured at rest correlated with the standard deviation of heart rates measured during the whole session ($r_{stda}=.54$, $r_{stdb}=.50$ and $r_{pNN50}=.37$);
- the HF in % of the total power correlated with both the minimal heart rate measured during the whole session and during just the form ($r_{\text{whole HR min}}=-.56$, $r_{\text{form HR min}}=-.75$);
- the LF/HF ratio correlated with both the average heart rate measured during the whole session and that of the form ($r_{\text{whole HR avg}}=.43$, $r_{\text{form HR avg}}=.43$).

Correlations between the cardiac regulative signs and the antropometric results

While the average heart rates measured during the whole training session correlated with all the antropometric parameters, the average heart rate measured during only the form, differing from other functional parameters, did not correlate with the antropometric variables, the only except was the body mass index. Independent functional parameters from the antropometric results were: resting average RR-interval, resting average heart rate, pNN50, maximal heart rate measured during the form and the whole session, and the standard deviation of heart rate measured during the form. The antropometric parameters independent from the functional ones were: relative bone mass, relative muscle mass and relative fat mass. Resting HRV variables correlated negatively with the decimal calendar age.

4.2.2. Effects of Taiji Quan practice on total antioxidant capacity

The practitioners SCS values were 38300±9394, 35680±10088 and 37480±10061 SCS scores. Both changes were significant (from the 1st to the 2nd measurement significant decrease, p<.001, from the 2nd to the 3rd measurement significant increase, p<.01).
According to gender, age, sport age, educational level and the chosen menu in the camp, there were no differences neither in the skin carotenoid levels, nor in the degree of SCS scores' changes. There were differences between the groups of different training time and the groups differentiated by nutritional habits, as in SCS scores as well as in the degrees of SCS changes. The more practicing peoples' SCS scores decreased in a smaller degree than those scores who practice less a week (-3.3% vs. -10.3%, p<.05) and their results were almost the same at the end of the training camp than they were at the start point, while the less practicing ones' results showed decrease (+1.0% vs. -5.3%, p<.05). Vegetarian had certainly higher SCS scores than meateaters (1st time 44667±9874 vs. 36902±8803, 2nd time 42222±11311 vs. 34244±9346, 3rd time 43444±11727 vs. 36171±9314, p<.05 in all cases), but their SCS values decreased only in the same degree than those of the other alimentary group.
Controls skin carotenoid level was 27133±10776 SCS. The whole Taiji group differed from controls both in SCS scores and some nutritional habits, as vegetable, fruit and red meat consumption, and also in the quantity of sweetening to their coffee or tea.

The SCS score correlated with the weekly Taiji training time (r_s=.35-.36), the weekly total (Taiji+other sports) training time (r_s=.34-.38), vegetarianism (r_s=.28-.32), daily sleeping amount (r_s=.30), subjective health (r_s=.36-.42), and with the satisfaction level with actual work (r_s=.29-.30).

4.2.3. Taiji Quan's psychological effects

The whole group's results were normal in all scales and factors. The GHQ results were excellent, median: 1.0, lower quartile: 0.0, upper quartile: 5,0, minimum value: 0.0, maximum value: 35.0.

The Multivariate Tests of Significance showed combined interaction effect of gender+training time for S-CPI scales (F=2.85, p=.03). Main effect for gender was significant in accordance with ACSI-28 factors (F=3.038, p=.009) and AAI test (F=3.622, p=.03); educational level modified the effect of training time on AAI results (training time's effect: F=3.468, p=.038, training time+educational level: F=4.186, p=.02). Combined interaction effect of gender, residence and training time predictors for PICI scales (F=2.138 p=.03) was found.

Gender differences

We found the following differences by gender:

- women had higher values in Trait Arousability (p<.01) and Feminity (p<.01);

- but men had better scores in Coping with Adversity (remains calm and controlled, positive and enthusiastic even when things are going badly, $p<.01$), Freedom from Worry ($p<.01$), in Confidence/Achievement Motivation (is confident and positively motivated; consistently gives 100% during practice and games and works hard to improve skills, $p<.01$), in Emotional Control ($p<.01$) and Irritability Control ($p<.05$) and also in Self-Regulating Subsystem (dominates over emotional-focused behaviour; regulates remaining in flow, providing the opportunity to fully dive into the task, $p<.05$).

Differences according to residence

- In Coachability ($p<.01$), Self-control (controls temper and emotions, self-disciplined, $p<.01$), Stability ($p<.01$), and Frustration Tolerance (quantity of frustration one can bear without changing his/her goals, $p<.03$), in Impulse Control ($p<.01$), Emotional Control ($p<.05$), and also in Self-Regulating – based on these scales – ($p<.01$) and Approach-Belief Subsystem (direct individual's outlook towards environment; facilitate the start of flow activities - searching for challenges, setting own goals, $p<.05$) countrymen had better results than townspeople.
- In Flexibility (likes change and variety, adaptable, $p<.01$), and Leader Flexiblity (flexible adaptation and enterprise, $p<.01$) townspeople reached higher scores
- A large difference appeared in Goldberg's Health Factor, countrymen's median point was 0.5 (lower quartile: 0.0, upper quartile: 3.0, min: 0.0, max.: 14.0), while townspeople's median was 2.0 (lower quartile: 0.0, upper quartile: 7.0, min.: 0.0, max.: 35.0). Mann-Whitney U Test proved better General Health in provincials ($p<.05$).

Differences by training time

There were differences between the groups of different training amounts in:

- Sense of Control (one's conviction of controlling his/her life, $p<.05$), and in Monitoring-Creating-Executing Subsystem (realize the fragile balance between the continuously increasing challenges and capacities, $p<.05$); in each scale subjects performing more training hours/week scored higher. There were almost significant differences between these groups in Creative Self Concept (the capacity of keeping one's values, $p<.058$) and in Challenge Orientation (openness, flexibility, proneness to following changes, $p<.053$), too, with higher scores at more training participants. Dominance (assertive, task-oriented, 39.6 ± 17.7 vs. 51.0 ± 15.9, $p<.05$) were also higher in subjects performing more training hours/week

Differences according to educational level

The only difference was that

- lower educated people had better Good impression making capability (tries to please others, 47.68 ± 5.37 vs. 38.74 ± 3.80, $p<.05$) than higher educated ones.

Combined effects

Apart from the main analyses by the four categorical predictors, some further, detailed analyses were made, in which we found the following combined effects of these predictors:

Gender and residence together showed a decisive effect in Trait Arousability, provincial males appeared to have the best (lowest) scores (24.7±6.7) among the different gender groups according to residence, and additionally, scores decreased further with more training time (22.3±6.0). The scores diminuted further on with higher educational level (19.2±2.5). The higher educated , more practicing provincial males showed significant difference with many other groups in Arousability: with lower educated, citizen, more and less practicing males (31.0±1.9 $p<.05$, and 34.8±8.2 $p<.01$), and with the higher educated, less practicing citizen and rural female groups (32-8±7-1 and 40.5±3.5, $p<.01$ in both cases), and also with the lower educated, more and less practicing rural women (30.9±4.1 and 31.8±5.7, in both cases $p<.05$).

The largest difference was in Coachability scores between citizen and provincial males (8.9±2.0 vs. 11.3±0.9, $p<.001$). In Intellect (openness, literacy, cultivation, 54.4±11.6 vs. 43.6±7.7, $p<.05$) and in Leader Flexibility (55.1±6.2 vs. 46.7±4.8, $p<.01$) female municipals had higher results than countryside's women, but males not.

More practicing women had significantly lower Socialization (conforms easily, accepts rules and regulations) than less practicing females (31.6±18.8 vs. 49.1±13.8, $p<.05$). More practicing males had higher Conscientiousness (the traits warranting effective work – tirelessness, accuracy, reliability, purposefulness) than less practicing men (51.6±11.1 vs. 36.5±14.8, $p<.05$).

More practicing citizen females had higher Flexibility than more practicing provincial females (73.7±11.5 vs. 38.8±10.4, $p<.05$). More practicing provincial females had lower Independence than less practicing citizen males and females (43.8±5.9 vs, 58.8±9.5 and 58.6±9.8, both $p<.05$). Municipal, more practicing females had the highest Leader Flexibility scores (63.0±3.5), and showed difference with less practicing citizen males, more practicing provincial males (50.4±7.6 and 49.9±3.3, both $p<.05$), and with less (49.2±5.1, $p<.05$) and more practicing provincial females (44.6±3.9, $p<.01$).

In Challenge Orientation (openness, flexibility, proneness to following changes) more training provincials reached higher scores than less practicing ones (15.5±2.1 vs. 12.2±3.6, $p<.05$).

Finally, we wondered whether Taiji practitioners do have fortes in personality traits or not. We compared the highest scores on each scale from person to person, and examined everyone's first three results. The three most frequently scales with the highest scores in the whole group were Flexibility (n=16, 73.3±13.5, for the whole group, the third strongest trait, group's mean±S.D.: 53.1±16.5), Achievement via Independence (strong drive to do well

through individual initiatives) (n=14, 7.86±8.0, the most pronounced trait of the whole group, group's mean±S.D.: 56.7±10.1), and on the third place, we found Feminity and Independence equally (n=12 equally, Feminity: 63.8±6.6, whole group's mean±S.D.: 50.7±11.9, Independence: 68.1±6.3, the second strongest scale in the whole group, group's mean±S.D.: 56.1±9.9).

Effects of different amount of Taiji practice (total number of years, total training hours)

After 3.5 years, Goal Orientation ($p<.05$), Coachability ($p<.05$) and Sociability increase ($p<.01$), after four years the Problem-Solving Capacity and Sociability augment (both $p<.05$).

Following 500 training hours, Confidence/Achievement Motivation ($p<.05$), after 1000 training hours the Goal Orientation ($p<.001$) and Sense of Control ($p<.05$) increase. Following 1500 training hours, beside the mentioned changes Problem-Solving Capacity ($p<.01$) and Creative Self Concept enhance ($p<.05$), and the latter remains higher after 2000 training hours than that of practitioners with less training time, too ($p<.05$).

5. Conclusions

5.1. Cardiovascular training-adaptive signs of combat sportsmen and martial artists

The detailed measurement of athletes' blood pressure pointed out that although, in general, physical activity has blood pressure diminishing effect, some kinds of sports – and static power sports belongs to these ones -, in a competitive level, raises the blood pressure over the level of controls and even over the normal values. Dynamic power athletes' (combat sportsmen and martial artists) systolic and diastolic blood pressure improved to be significantly lower than static power athletes' values. Based on these results we do not find right the synthesis of these two groups. We found further fine differences between the different martial artists' groups. Muay thai seems to have the highest static load, higher than kung fu or karate. Inspite of judo contains many static elements, too, judoists had the lowest systolic blood pressure values which can be the result of the scientific background of the judo trainings, since judo is an Olympic sport, so there is an expanded care in it. Taiji practitioners' results testify that they should use more dynamism in their practice.

Further indicators for the differentiation of combat sportsmen and martial artists from static power athletes that their heart rate, blood pressure, E/A ratio, relative left atrial diameter and velocity of circumferential fibre-shortening values resemble rather to the results of endurance athletes, and in all the parameters their results significantly differ from those of static power athletes, except in E/A ratio. The background of these distinctions probably is the martial arts' and combat sports' combined endurance-, static and fast power-, and dynamism-needing movement repertory. All types of dynamic power sports enhanced the left ventricular muscle mass.

5.2. Chen-style Taiji Quan's further effects on health

5.2.1. Chen-style Taiji Quan's effects on resting heart rate variability and heart rate changes during exercise

Chen-style practitioners' cardiac regulation is basically alright (heart rate, pNN50, index stda and stdb, standard deviations), and with personal consultations their results can be improved. Although Taiji practitioners didn't have training-induced bradycardia, their Index stda and Index stdb values more or less were in the range as those of elite athletes. The typical fast and slow, hard and smooth movements in the style, carried out alternately approx. in equal quantity, appeared also in the practitioners' LF/HF ratios which were near to 100%. Practitioners' pNN50 values in most of them were over 10%.

Chen-style Taiji Quan practice gives a little bit higher cardiac load than other styles of Taiji Quan. Regular measurement of HRV can help to make a good personal training program to everyone, to a certain extent the individual's developement will be predictable and his/her cardiac status can be kept in the optimal interval, for an exercise physiologist it can help even in reaching the best status of an Olympic athletes. Relying on the fact that the investigated

Taiji participants had practiced for at least 3 years, long-term, continuous Taiji practice seems to have protective effect on the cardiovascular system, and to hold the autonom nervous system in balance.

5.2.2. Effects of Taiji Quan practice on total antioxidant capacity

The long-term Taiji practice increases the antioxidant level (The Taiji practitioners' results were 29.1% higher than the controls' scores). The five-fold quantity of the weekly habitual practice did not diminish too much the skin carotenoid level. The whole Taiji group's nutritional habits match to the current nutritional recommendations; just some of the practitioners use dietary supplements. Practitioners' regular vegetable and fruit consumption is not enough explication to their high skin carotenoid scores. Not even Taiji as physical activity gave totally satisfactory explanation for these high scores. The correlation of SCS scores with mental/psychic health, together with the mentioned possible modifying factors maybe can prove an acceptable reason for Taiji practice's such antioxidant-level increasing effect, hence Taiji's beneficial psychological effects are already known. Nevertheless we wish to remark that none of the training sessions contained meditation.

Thus, the practice of the so-called Qi-developing Taiji Quan augments the antioxidant capacity. Nowadays, in the National Geographic Channel's program called: 'Stealth fighters', biomedical engineers tried to find the way to measure the power of Qi, but their methods weren't able to catch it. In this study, if not surely the Qi itself, but we think at least one of its effects we could demonstrate.

5.2.3. Taiji Quan's psychological effects

Although our study was a cross-sectional study and probably these findings need further, higher-level trials for confirmation, it had some new aspects we think they are worth to consider.

1) Practice of Taiji improves general mental health at least in that extent like other physical activities.
2) The excellent Trait Anxiety and Trait Arousability levels are the results of Taiji's calming effect.
3) Among personality traits, Flexibility, Independence and Intellect dominate characteristically among Taiji practitioners. Besides being really purposeful, self-reliant, and creative, they are also compliant, sociable, and unaffected. Maybe this duality is the exhibition in the psychological traits of the Chen-style's alternately used hard and gentle techniques.
4) Taiji seems to strengthen psychological immune competence, improves almost all aspects, ensures positive thinking, practitioners understand better the life-events, sense their psychological development, are more resourceful, well-synchronized with life-events, and can control their behaviour, emotions and reactions to frustration well; and in their social relation-

ships both their sympathizing, as well as directing and creative capabilities prevail. Provincial practitioners rather seem to have spiritual disposition, while more training ones have increased creativity and social openness compared with the average population and elite athletes.

5) Taiji practice has no special effects on genders.

6) More Taiji practice leads to better Sense of Control, to higher Dominance and better cooperation with the world.

7) Provincial practitioners are more stable, they have better self- and emotional control, and they are obedient, while the practitioners from the capital are more flexible.

8) Educational level had no extra effects.

9) Sport-relevant coping skills do not increase in Taiji practitioners in such degree like in other athletes. We can attribute it to Taiji practice's different capability-needs – meditation in movement, calming down, concentration inside – opposite to outer concentration, and achievement constraint of other sport activities. The more Taiji practice's Sense of Control- and Dominance-increasing effect, the presence of Sociability, decreased Anxiety and better general mental, following some years of practice, are common concomitant of sports activeties. Otherwhile, Taiji practitioners' psychological immune competence is perfect, even better than that of elite sportsmen.

As we used rather different questionnaires than other authors having studied Taiji's effects, we could not compare these results, but we share the opinion that for the lot of stress, depression and feeling of incapability, which are actual public health problems, physical activity can have a facilitating effect on them. Additionally, as not anyone can do any kind of sports, Taiji, with its moderate intensive, slow movements, giving calm and refreshment, presumably could be a good choice in a broad circle of people for their psychological and/or physical symptoms, not speaking about its remarkable personality and psychological immune competence developing effects, which demonstrate that this leisure-time activity's really worth the attention.

Candidate's own publication list

Publications related to the thesis

1) Varga-Pintér B, Kneffel Zs, Petrekanits M, Pavlik G. (2007): Küzdősportolók echokardiográfiás vizsgálatának eredményei [Echocardiographic data of combat sportsmen]. Magyar Sporttudományi Társaság, VI. Országos Sporttudományi Kongresszus. Congress Book, CD version. (ISBN: 978-963-87701-2-7).
2) Horváth P, Petrekanits M, Györe I, Kneffel Zs, Varga-Pintér B, Pavlik G. (2009): Echocardiographic and spiroergometric data of elite Hungarian female water polo players. Acta Physiologica Hungarica, 96(4):449-457.
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6) Varga-Pintér B, Petrekanits M, Kneffel Zs, Tóth M, Pavlik G. (2011): Chen-stílusú Taiji gyakorlók nyugalmi szívfrekvencia-variabilitása és edzés közben mért pulzusszám változása [Resting heart rate variability and heart rate changes during exercise of Chen-stly Taiji practitioners]. Sportorvosi Szemle, 51(4): 123-131.
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Publications list not related to the thesis

1) Bíró L, Rabin B, Regöly-Mérei A, Nagy K, Pintér B, Beretvás E, Morava E, Antal M. (2005): Dietary habits of medical and pharmacy students at Semmelweis University, Budapest. Acta Aliment, 34: 463–471.
2) Kneffel Zs, Varga-Pintér B, Tóth M, Major Zs, Pavlik G. (2011): Relationship between heart rate and E/A ratio in athletic and non-athletic males. Acta Physiologica Hungarica, 98(3): 284-293.