

PSYCHOLOGY

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Stress Induced Changes in Neurotrophic Mechanism and Mind Set of Martial Art Practitioners: A Systematic Review

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Abstract

Background. Regular martial art practice develops synergy between the psychophysiological self and the neurocognitive mechanism within the body. The Zen tradition of this training on mind sets helps manage stress, and improve cognition and neural control with enhanced neurotrophic signaling.

Aim of the study. The present review tries to liberate the interplay between neurochemical secretions, and their relationship in respect to martial art practitioners. The interaction between two neurochemicals, Brain Derived Neurotrophic Factor (BDNF) and Cortisol, on the different mind sets in three martial art forms - *karate*, *judo*, and *taekwondo* have been highlighted in this study. **Method (acquisition of evidence).** PICOS strategy was adopted in a compilation of the data sources, which elaborated data extraction in relation to its Participants, Intervention, Comparison, Outcomes and Study design for the numerous literature that were surveyed. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) was applied to screen, collaborate and synthesize the items for the present study.

Results (evidence synthesis). Selected studies on minute and critical reviewing evidently showed that regular martial arts training could improve neurocognition and neurohormonal homeostasis, a major setback being limited research in this area.

Conclusions. Data from the present findings suggest that martial arts training in regular, repetitive patterns can reduce cortisol levels and improve neurotrophic outcomes in the form of elevated secretions of BDNF. Comparative and individual inferences to prove the efficiency of martial art forms better require further research.

Background

This systematic review attempts to foreword the pertinence of neurotrophic aspects of martial arts training, its relation to stress and neural networking through brain neurochemicals. Traditionally, an Eastern Zen philosophical teaching concept, this art has its hard and soft styles, based on the way energy known as “ki”, “chi” or “qi” reaches the target [Fuller 1988; Kunen 2014]. Regular practice of this moderate-intensity aerobic exercise creates awareness to make a paradigm shift from a fixed mindset to a growing one [Suzuki, Dixon 2007; Dweck *et al.* 2019], disciplines the thought process, and develops etiquettes in a ritualistic manner [Donohue 1993]. This personality of a martial artist is visible to the entire

world, but what goes on within the brain to mould them into such mindful, alert, visionary, focused individuals are a question not hypothesized too often. There is no such compilation presented earlier, based on the Zen aspect of three hard-martial art forms; karate, judo and taekwondo in relation to neurochemicals.

Existing Body of Knowledge and Provocation of Thought

The current knowledge about martial arts training revolves around it as an aerobic intervention to improve physiological profiles relating to improved cardiovascular [Slimani *et al.* 2017; Bhattacharya, Chatterjee 2020],

musculoskeletal, and postural fitness [Cromwell *et al.* 2007; Douris *et al.* 2004], self-efficacy [Douris *et al.* 2015], cognition [Witte 2015; Bodin, Martinsen 2004], and attention [Johnstone, Mari-Beffa 2018].

There are reports of these training forms having a close connection to improve stress tolerance [Douris *et al.* 2015] and coping with stress [Budnik 2010] along with a reduction in aggression [Harwood *et al.* 2015] and anxiety [Vertonghen *et al.* 2010]. There are some research studies performed on their neuroprotective aspects, for autism [Bahrami *et al.* 2016], epilepsy [Conant *et al.* 2008], attention deficit hyperactivity disorder (ADHD) [Palmero *et al.* 2006] and Parkinson's disease [Dahmen-Zimmer *et al.* 2017] which prove it helps to reduce depression. But a clear picture of the interplay between the neurochemicals is quite sparse. The philosophical roots of the three martial arts considered include *Karate-Do*, *Judo*, *Taekwondo*, they have “do” in common which means “the way”. More precisely so, karate means the empty-hand way and another meaning to it by its founder Gichin Funakoshi was to “empty the mind” based on Zen philosophical thought, while Judo means the gentle way to self-realization and Taekwondo means the right way of using the fists and feet, to keep calm [Ahn *et al.* 2009].

The human neurocognitive foundation lies within the hypothalamic-pituitary-adrenal axis. This axis regulates the secretion of various hormones activated through a regular practice of martial art which in turn provide several psychophysiological benefits.

A reported few include a study on a group of athletes trained on mental imagery through judo training showed immense situation coping, changing strategy skills and critical situation perception [Chalgaf *et al.* 2013]. Cognitive development of experienced martial art practitioners was evident on alert networks and proved that with experience the endogenous alert gets benefited [Johnstone, Beffa 2018]. A comparative study between functional aspects of martial art practitioners and control group analyzed a significant difference and higher levels of self-efficacy, self-esteem and a decreased aggressiveness among martial artists [Fabio, Towey 2018]. Taekwondo training as a security martial art increased maximal oxygen uptake, anaerobic threshold and cardiorespiratory fitness, along with blood lactate levels. These parameters of improvement reported better security services in emergencies [Kim, Seo, Choi 2014].

Research on cognitive and exercise psychology explains attentional mechanisms mediated through anxiety-performance relationships and neurophysiological endorphin secretion principles [Weinberg, Gould, 2011]. These neurohormonal secretions and the adaption to stress play a pivotal role in psychophysiological homeostasis [Selye 1950]. Stressor specific responses help in the restoration of body-mind balance and produce long term benefits to the individual, these are eustress [Dhabhar 2018].

However, if the stress persists, cumulates with maladaptive conditions which are deleterious to health it phases out to distress [Moberg 2000]. Mind-body exercise like martial art act as specific eustressors which help relieve stress [Esch *et al.* 2007]. Neurotrophic factors play an important role in neuronal survival, neuronal protection and neurogenesis, to improve brain health [Lee *et al.* 2014; Numakawa *et al.* 2011]. And also in the reduction of stress and its related hormones [Groves 2007].

The relationship between two neurochemicals BDNF and Cortisol in the brain of martial art practitioners has a close interaction which equates it to moving meditation especially due to its Zen practices and certain psychophysiological engagements which are discussed in this review.

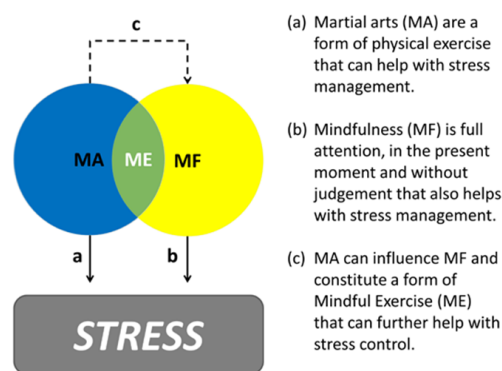


Fig. 1. Reciprocal relationship between Martial Art, Mindfulness, Mindful Exercise and Stress [Naves-Bittencourt *et al.* 2015: 34-51]

Brain-derived Neurotrophic factor is one of the major mediators of the neurotrophic mechanism and plays a complex plethora of activity-dependent regulation within the hippocampus, prefrontal cortex and the amygdala [Vaynman *et al.* 2004; Voss *et al.* 2013]. At the molecular level exercise-induced BDNF stimulates the production of proteins which help in cellular stress adaptation, improvement in learning and memory along with neuroplasticity [Walsh, Tschakovsky 2018].

Stress is a result of abnormal cellular metabolism and this leads to an increased reactive oxygen species (ROS) production [Schieber, Chandel 2014]. In order to return to the normal homeostatic state, a hormetic condition may develop and cause a rise in synaptic plasticity and neurocognition to reach an adaptive condition better than the previous [Wu *et al.* 2004; Lopez-Diazguerrero 2013]. An increase in peripheral serum and plasma BDNF is well established for acute manageable stress which is best controlled in the form of physical exercise [Erickson *et al.* 2011]. These acute stress conditions are commonly created in martial art training and this could be a reason for increased neurotrophic activity in such practitioners as well [Roh *et al.* 2020].

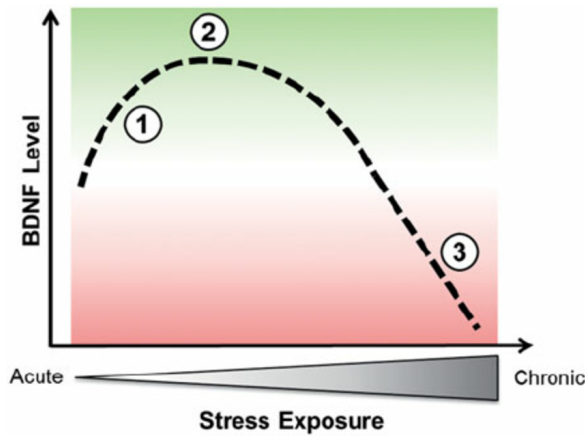


Fig. 2. Conceptual Biphasic representation of BDNF induced by Stress [Schmitt *et al.* 2016: 42-51]

Stress and BDNF maintain a hormetic dose-response relationship as seen in Figure 2 [Schmitt *et al.* 2016]. Point 1 shows the increase in BDNF during acute stress condition this become Eustress in martial art training which is provided to the practitioners as a cue to habituate to chronic stressful conditions either on the competition arena or out in open as self-defensive combat. Point 2 illustrates induced increment due to synaptic transmission and plasticity, while point 3 shows a fall in BDNF levels due to harmful effects of chronic stress, which reiterates the proposition of the neurotrophic theory of depression [Duman, Monteggia 2006]. Neural activity and neurocognitive connectivity rely on a continuous energy supply and oxygen supply to maintain its functioning within the brain [Walsh, Tschakovsky 2018]. This disruption of energy by stress can negatively impact the neurotrophic mechanism [Miranda *et al.* 2019]. There

are studies which show that oxidative stress and BDNF have a negative correlation and elevated ROS species also cause a decrease in BDNF and neurogenesis [Roh *et al.* 2020]. Martial art training can reduce oxidative stress by inducing antioxidant mechanisms. This condition of chronic stress can also be avoided as all the cues to increment stress in the brain of martial art practitioners are kept away with their contemplating mind sets and focused mind energy, to bounce back with a motivated approach, illustrated in Figure 3.

Aim of the Study

Despite the knowledge about various martial art training to improve mind body functioning with improvement in neurocognition, there is no review study which elucidates the pooled analysis or documentation of the various published research in the communication of neurochemical pathways. Thus, the ultimate idea is: to investigate the consequences among the three most popular hard martial art style practitioners; karate, judo and taekwondo in response to the interaction with two major neurochemicals; Brain-Derived Neurotrophic Factor (BDNF) and Cortisol (Stress Inducing Factor)

Evidence Acquisition / Method

Eligibility Criteria

Specific study characteristics and report characteristics of the present study were conducted according to the Preferred Reporting Systematic Reviews and Meta-Analysis (PRISMA) [Moher *et al.* 2009].

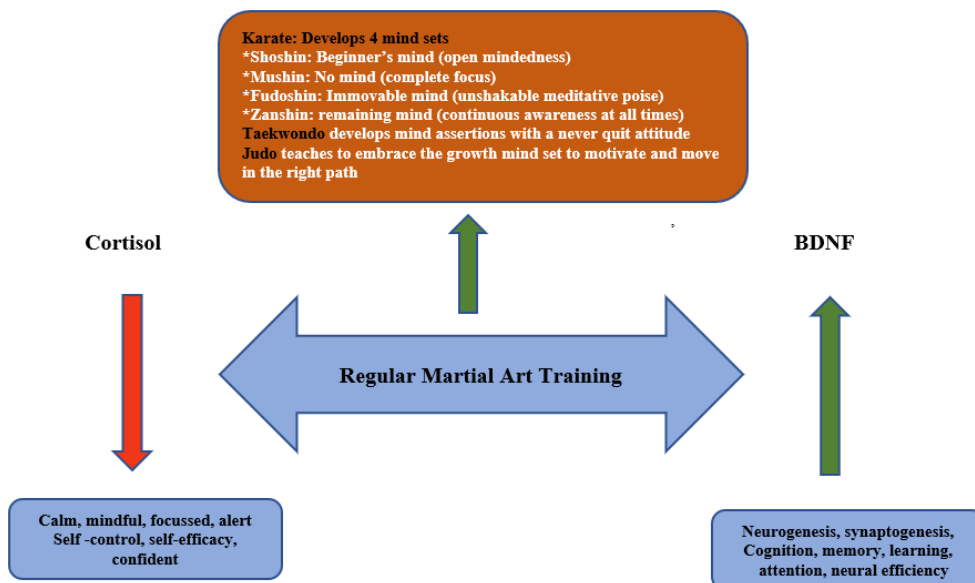


Fig. 3. Effects of regular martial art training on Cortisol, BDNF and developing growing mind sets [self-sourced]

The study eligibility criteria include:

1. Population for the study included three hard martial art practitioners from karate, judo and taekwondo
2. Interventions selected included training protocols in karate, judo and taekwondo for at least a minimum of six weeks.
3. Comparators: Exercise groups versus Control groups
4. Outcomes: Growth mind sets develop in the regular selected martial art practitioners and the Neurotrophic increased with regular training, stress-inducing variables like cortisol decreased reducing anxiety and stress in the long run.
5. Study designs included: Randomized control studies and evidence-based studies.

The report eligibility criteria included the following:

1. Publications in the English language were only considered for the study
2. Only published articles and full texts were included
3. The data were extracted till April 2020 with no start date
4. Certain studies were excluded as they did measure cognitive outputs but following electrophysiological methods or audio-visual and spatial procedures thus were not included in the present study.

Information Sources and Data Collection

PubMed, Medline, Academic Premier, Google Scholar, Science Direct, Archives of Budo, SPORTDiscus were

the search engines thoroughly looked into, with no start date, up to April 2020. The rigorous search included the following terms “martial art and stress”, “martial art and BDNF”, “martial art and cortisol”, “martial art and neurochemicals”, “martial art and stress tolerance”, “martial art and meditation”, “martial art and neurotrophic factors” and the same terms with each of the three selected styles were also searched. The data was extracted from various studies which included experimental studies and review papers related to the sourced search. The data collection process was completely in alignment with the PICOS strategy mentioned in the eligibility criteria method of selection.

Study Selection

The eligibility assessment was performed by two reviewers in an unblinded manner. The selected manuscripts from each database downloaded into a single reference list duplicates were eliminated. Titles and the abstracts were then screened for eligibility and full text articles on karate, judo or taekwondo intervention on any age group testing variables of neurotrophic nature or stress-inducing hormones were kept. Full-texts were read and confirmed by both authors for inclusion and exclusion. Any disagreement between the two reviewers was resolved by a consensus meeting, a fair agreement index was obtained at 74.2857%, Cohen's k: 0.326923 [McHugh 2012]. One

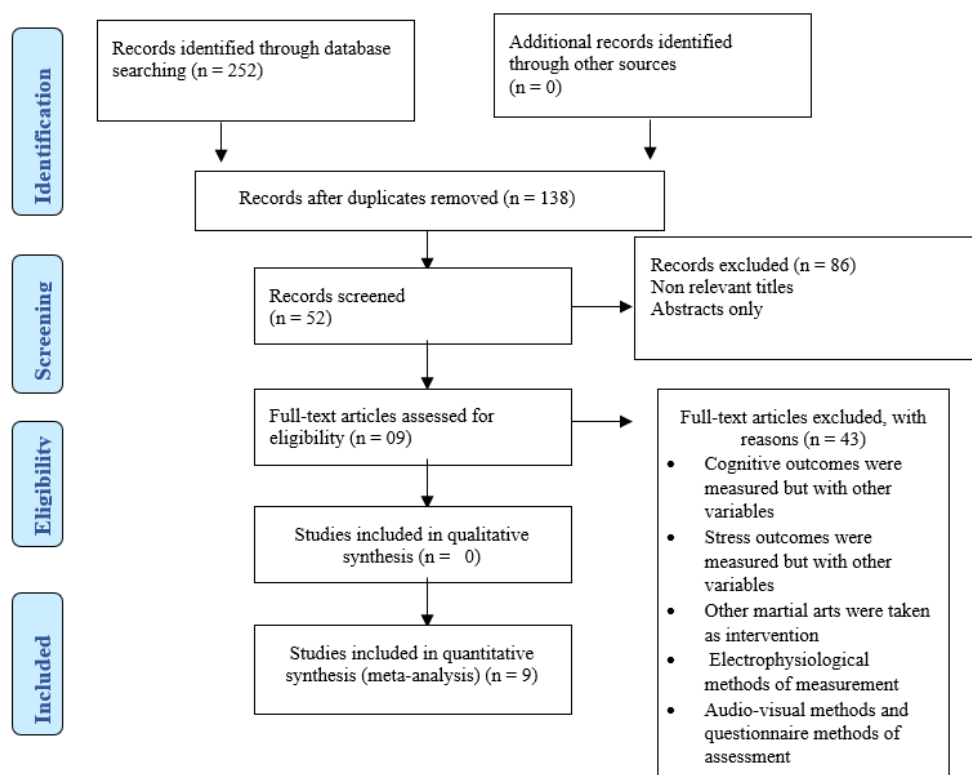


Fig. 4. Flow Diagram of the selected studies through PRISMA guidelines [Moher *et al.* 2009]

author was contacted for further details on a particular study intervention. Initial database search identified a total of 252 records. Once the duplicates were removed 138 abstracts and titles were checked for inclusion and a total of 52 studies were extracted as full texts and checked for eligibility. The full texts were examined and 43 did not meet the inclusion criteria. 9 studies that met the criteria were kept in the final quantitative synthesis of the review. The flow chart of the study selection process is shown in Figure 4 [Moher *et al.* 2009].

Evidence Synthesis / Results

Findings

A total of nine studies on the relation between martial art and neurochemicals were extracted as seen in Figure 4 [Moher *et al.* 2009]. These studies involved between twenty and eighty subjects, a heterogeneous demonstration of various martial art interventions, different experimental designs and time periods were seen. The extracted studies have been presented in two tables (Table I and II) according to the variables measured (Cortisol and BDNF). Most of the studies on stress used questionnaires, stress tolerance scale and anxiety tests which were not considered. Only two studies measured cortisol levels directly, one measured pre- and post-karate intervention changes [Jansen *et al.* 2017] and the other observed hypothalamic-pituitary-adrenal axis in long term karate practitioners [Vera *et al.* 2018]. Both studies were on karate training; no studies were reported on judo or taekwondo (Table 1). The neurotrophic mechanism was determined by considering studies that directly measured BDNF, seven studies met the criteria and were included (Table II) of which one had karate athletes as the subjects [Mehrijardi 2017] one with elite judo athletes [Schor *et al.* 2019] and the remaining five studies were on taekwondo training [Roh *et al.* 2020; Cho, Roh 2019; Cho *et al.* 2017; Kim 2015; Oztasyonar 2017].

Martial Art and Cortisol

Table I summarizes two martial art randomized control studies both on effects of karate training. Stress cortisol levels in the first study with three comparator groups; karate group, mindfulness-based stress reduction group and control group showed little association with self-reported stress. The karate group did not show significant improvement in the stress variable cortisol. In regard to the self-reported chronic stress, the RM ANOVA yielded no significant main effects of group or time. Concerning stress from lack of social support the karate group did not improve significantly from pre to post-assessment ($p=0.576$), however MBSR group showed a trend of decreased stress. While the second study which compared male karate practitioners to active male adults the intervention for the experimental group was a typical

session of karate training in forms of *kata*, short combat drills and *kumite* which were commonly practised by the practitioners in their *dojo* two to three days a week as a routine for more than three years. Hormones from the hypothalamic-pituitary adrenal axis and hypothalamic-pituitary-thyroid axis were drawn from the active controls and the karate practitioners, Mann-Whitney U test was conducted to analyse the differences. The main finding highlighted that regular karate trainers experienced a significant decrease in levels of cortisol and thyroid hormones [Vera *et al.* 2018].

Martial Art and BDNF

A total of seven studies with fourteen to eighty participants measured BDNF levels to study neurocognitive functioning in response to martial art training are presented in Table 2. One study was on karate training, one on judo athletes and the remaining studies were on taekwondo (TKD) interventions in various age groups. However, two studies one with eight weeks of endurance training, three days a week apart from regular karate training at an intensity conforming to 50-60% VO₂Max for forty-five minutes, conducted on ten female karate athletes and another study with eight-week TKD intervention on undergraduate students eighty-five minutes a day five days a week; showed slight deviation. Both these studies resulted in an increase in BDNF levels (ng/ml) in the karate training group from 2.9 ± 1.4 to 3.2 ± 1.5 , and TKD training group from 1.23 ± 0.56 to 1.58 ± 0.36 but results were statistically insignificant [Mehrijardi 2017; Schor *et al.* 2019]. Contrastingly, a six-week TKD training in overweight and obese population of young adults $n=20$, the oxidative stress is reduced and BDNF levels rise significantly from pre to post exercise ($F= 6.767$, $P=0.018$) [Roh *et al.* 2020].

On the other hand, fifty-six elite judo black belt athletes from the Brazilian Judo team with ten years of Judo training experience or more than fifteen hours of training per week were randomly divided into two groups. Twenty-five (fifteen women aged 23.3 ± 0.8 , and ten men aged 25.3 ± 1.0) did Randori training and thirty-two athletes did ramp test (sixteen women aged 23.3 ± 0.8 and sixteen men aged 24.2 ± 0.8). The Judo intervention of randori included a ten-minute warm up and judo randori fights of three minutes each followed by three minutes of rest for one hour. Following which one minute of high – intensity judo strokes were performed. The (MIRT) Maximal incremental ramp test included three minutes walking at 20W/kg, followed by 25 W / kg steps very 30secs. The results indicated significant increase in BDNF in both the groups, however the delta BDNF in the Randori group was higher (457.7 ± 24.8 %) than the Ramp test group (268.8 ± 24.8 %). Higher basal BDNF was also seen in women than men in both the groups [Cho, Roh 2019].

Two studies on a sixteen-week TKD intervention on twenty young school-going children and the other

Table 1. Summary of studies with cortisol as a stress measure

Study reference	Population and study design	Study Design	Intervention	Comparators	Stress Measures	Conclusion
Jansen <i>et al.</i> 2016	Healthy inexperienced n = 55 (age: 63.5 ± 5.7) 21 male, 33 females, 1 unmentioned	Randomized Control Trial (RCT)	Karate / Mindfulness based stress reduction (MBSR) pre and post intervention. 8 weeks, 15 training sessions (M= 13.0 SD=1.75), twice a week. With one week as an exception in which training was performed only once due to holidays.	Karate vs MBSR vs Control	Stress Cortisol did not show significant improvement. The shift in stress from lack of support pre to post assessment was p=0.576	Emotional and Cognitive well being showed improvement in the karate group. But hair cortisol measurements reflected otherwise. But karate training adhered high therapeutic adherence.
Vera <i>et al.</i> 2018	Healthy Adults n=22 (18-55 Years) Karate practitioners (age 36.83+14.15) with minimum three years training experience n=12 (M=4.05, SD=0.76) Active controls=10 (age: 28.50+10.45)	Evidence based Study - Practice (EBP)	Karate practitioners Performed regular Practice of kata, Combat drills and kumite one hour two to three days a week with three years' experience (M= 4.05, SD = 0.76) and ten age-sex matched active disease and drug free healthy male adults as the control group, selected by interview using STAI (Spielberg-State-Trait Anxiety Inventory).	Karate versus Control	Downregulation of HPA axis in karate group. Cortisol levels in Karate group: M= 14.04 SD=2.96 Control group: M=17.55 SD= 6.04.	Endocrine modulation in karate practitioners shows karate as an effective psychobiological tool.

Table Note: Pooled evidence synthesised two studies on karate training and cortisol levels.

Table 2. Summary of studies with BDNF as a Neurotrophic measure

Study reference	Population and study design	Study Design	Intervention	Comparators	BDNF Measures	Conclusion
Mehrjardi 2017	Female karate athletes n=20 Ten in exercise group and ten control group	RCT	Intervention: Endurance training three days a week for eight weeks forty-five minutes per session at 50-60% intensity, with individual VO2 Max consumption	Karate athletes in exercise group vs karate athletes in control group	Post exercise BDNF rise in the exercise group from 2.9 ± 1.4 to 3.2 ± 1.5 Not significant	Possible reasons for no significant rise in BDNF: No significant reduction in body weight and BMI, in fact slight rise in body mass. Maybe no training effect in the intervention duration of eight weeks.
Kim 2015	Undergraduate students n=14 was put into the Taekwondo Exercise group n=7 and Control n=7	RCT	Exercise group performed Taekwondo training for eight weeks at 85mins per day five days a week	Exercise group vs control	BDNF showed a slight tendency to rise. 1.23 ± 0.56 1.58 ± 0.36 Not Significant	Cognitive tests showed positive significant improvement in the exercise group however the Neurotrophic factors did not show significant increase post training.
Roh <i>et al.</i> 2020	Adolescent Overweight n=20 Control=10 (7 boys/3girls) Exercise group=10 (7boys/3girls)	RCT	60 minutes five days a week for sixteen weeks	Exercise group (Taekwondo) vs Control	BDNF as a myokine showed significant increase from pre to post intervention: 25.41 ± 5.36 to 29.52 ± 5.83	Taekwondo training reduces oxidative stress and increases BDNF levels.
Schor <i>et al.</i> 2019	Elite Judo athletes n=56 Randori Group n=25 MIRT (Maximal Incremental ramp test) n=32	RCT	One session of randori training of one hour for the randori group. Maximal incremental ramp test for the MIRT group	Judo international Brazilian team athletes in the randori group vs the same level athletes in the MIRT group	BDNF levels in men and women in both groups showed significant rise. However, the randori group showed higher rise in BDNF levels	Reasons for high increment specific complex actions in a real competition like situation and as homogeneity in both groups was maintained and they were well experienced and regular trainee practitioners.
Cho, Roh 2019	Elderly women (< 65years) n=37 Randomly into Taekwondo group (TKD) N=19 Control n=18	RCT	TKD training protocol one hour, five days a week at HR Max 50-80% for 16 weeks	TKD group vs Control	Serum BDNF measures showed significant rise in TKD group from 24.03 ± 6.16 to 27.62 ± 7.58	TKD practice can lead to rise in neurotrophic growth factors similar to aerobic exercise, to improve neurocognition in elderly.
Cho <i>et al.</i> 2017	Young school going children n=30 Taekwondo group n=15 (9 boys, 6 girls) control group n=15 (9 boys, 6 girls)	RCT	16-week TKD protocol five times a week with 11-15 training sessions, each 60minutes of a perceived exertion (RPE) of 11-15	TKD group vs Control Group	Serum BDNF levels show significant increase in the TKD group from 22.61 ± 7.77 to 25.64 ± 7.87	TKD practice can lead to rise in neurotrophic growth factors similar to aerobic exercise, to improve neurocognition in children.
Oztasyonar 2017	International & National players n=80 Four groups N=20 Group I: Sedentary Group II: Athletes Group III: Boxers Group IV: Taekwondo players	-	Intervention for two hours six days a week	Sedentary vs Athletes vs Boxers vs Taekwondo players	BDNF showed increment in the following order post training taekwondo > boxing > athletes > sedentary.	Due to high attention and concentration in combat sports

Table Note: Pooled evidence summarised seven studies on karate training and cortisol levels.

on thirty-seven elderly women showed a significant elevation in levels of serum BDNF measured by two-way ANOVA ($F=9.142$, $p=0.005$), pre-test to post-test showed 24.03 ± 6.16 to 27.62 ± 7.58 in the TKD group of school-going children and the pre to post TKD intervention increase was 22.61 ± 7.77 to 25.64 ± 7.87 ($F=8.42$, $p=0.006$) for the elderly women who performed TKD training [Cho *et al.* 2017; Kim 2015].

The two-hour intervention of respective training six days a week in international and national practitioners belonging to the athlete group, boxer group and taekwondo group and one sedentary group as a control group were tested. Pre-Training BDNF ranks; taekwondo > boxing > athletes = sedentary converted to; taekwondo > boxing > athletes > sedentary post-training [Oztaşyonar 2017] Pooled analysis of all the studies, showed a significant rise in BDNF levels and concluded that regular, consistent martial art training could enhance neurotrophic secretions.

Discussion

Summary of Evidence

The overall strength of the evidence achieved may not be sufficiently robust, however the relevance of martial art training as a neurocognitive intervention is decisive. Studies on neurochemical secretions and martial art are very limited, but the available data speaks volumes and martial art training can achieve immense acceptance as a meditative art form. It is reported to comprise yogic and mindfulness aspects of meditative nature [Diamond, Lee 2011] and helps to remove distress. Substantial acceptable indications suggest that martial art training in any of the three styles considered karate, judo and taekwondo, if performed with proper intensity and duration (minimum sixteen weeks) will show apparent improvement in BDNF and also help in the reduction of cortisol. The movements in all three martial art forms consist slow and fast actions synchronised with breathing patterns involving deep focus and imagery of the opponent for better practical application. The emphasis of this study was on three basic martial art forms from the many available options, the reason has been clearly depicted in Figure 3. The philosophy of these very ancient martial art forms is based on mind sets which show great inclination towards neurocognitive growth. The mechanism of the review was based on the hormetic stress response on cellular stress pathways and its relation with neurotrophic theory of depression with special reference to Brain-Derived Neurotrophic mechanism – BDNF and Cortisol. The evidential summaries are ranged between the last five years as the relation between neurotrophic mechanism and exercise had begun a decade ago but the hormesis and homeostasis involvement in martial art forms came up much later. The variety of aspects in

these art forms commonly called kihon (basic forms), kata (sequence of attacks and defense) and kumite (free fighting) improve neurophysiological homeostasis of the body. These art forms practically create conducive stress environments during training which cognitively develop the mind and body to face distress with restraint and calm. Parasympathetic and neurocognitive dominance in such mind sets should be clearly evident on the direct study in this line.

11. Limitations of the Study

The quality of compiled studies showed immense variations some were typical RCTs but some did not ascertain the study design. The interventions period was unclear in one study while the outcomes in correlations according to the researchers of another study were unexpected, the researcher attributed that the subjects with higher initial stress were under considerable strain with respect to the success of the training intervention as they were relatively eager to feel much better after the training and could be that they were somewhat disappointed as the changes were relatively small [Jansen *et al.* 2017]. Two eight-week training interventions one karate [Mehrjardi 2017] one TKD [Schor *et al.* 2019] showed no significant increment in BDNF levels, while one six-week TKD intervention on obese / overweight subjects gave significant increase in BDNF [Roh *et al.* 2020]. One of the reasons for this could be intensity of the training which resulted in a significant reduction in body weight in the obese subjects from 58.34 ± 7.13 to 55.99 ± 6.53 , while in the two eight-week intervention studies body weight almost remained unchanged in the TKD training and increased in the karate training group post-intervention. So, body weight may have an interplay with BDNF secretion.

Common sense acclaims that a moderate-intensity physical activity teaching ritualistic self-control, self-compliance, discipline, goal directed attention and reduction of aggressive behaviours should be effective as a stress buster, a neurocognitive inducer and meditative mediator. However, documentation and backing from the scientific literature are what lacks this art form. The present researcher adheres to comply with experimental studies on martial art training to fill the gaps presently seen in this area.

Conclusions

Between 2015 and 2020 nine experimental studies of the effect of BDNF and Cortisol were reviewed. The interplay between cortisol, BDNF and mind sets of martial art practitioners completely depends on a dose-response relationship of the type of training intervention, its duration and design. The different styles involved in martial

arts like karate, judo and taekwondo may be ancient art forms with mental inclination but they have recently become popular as a sport. Thus, the traditional teachings and challenging neurophysiological implications are unknown to many. These ritualistic eastern martial art forms can be conveyed as mind body interventions and help reduce stress and improve neurotrophic aspects to build growing mind sets among a population of all age spans.

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Zmiany w mechanizmie neurotroficznym wywołane stresem i nastawienie umysłu praktykujących sztuki walki: Przegląd systematyczny

Słowa kluczowe: psychofizjologia, mechanizm neurotroficzny, tradycja Zen, wydzielanie neurochemiczne, homeostaza neurohormonalna

Streszczenie

Wprowadzenie. Regularna praktyka sztuk walki rozwija synergię pomiędzy jaźnią psychofizjologiczną a mechanizmem neurokognitywnym w organizmie. Tradycja zen tego treningu na nastawienie umysłu pomaga zarządzać stresem, poprawia poznanie i kontrolę neuronalną z wzmocnioną sygnalizacją neurotroficzną.

Cel. Celem niniejszej pracy jest ukazanie wzajemnych oddziaływań pomiędzy wydzielanymi neurochemikaliami i ich relacji w odniesieniu do osób uprawiających sztuki walki. W niniejszym badaniu opisano interakcję pomiędzy dwoma neurochemikaliami, *Brain Derived Neurotrophic Factor* (BDNF) i kortyzolem oraz ich wpływ na różne nastawienie umysłu w trzech formach sztuki walki - karate, judo i taekwondo.

Metoda. W kompilacji źródeł danych przyjęto strategię PICOS, która umożliwiła ekstrakcję danych w odniesieniu do uczestników, interwencji, porównania, wyników i projektu badawczego dla licznej literatury, która została poddana przeglądowi. W celu przesiewu, współpracy i syntezy pozycji dla niniejszego badania zastosowano *Preferred Reporting Items for Systematic reviews and Meta-Analyses* (PRISMA).

Wyniki. Wybrane badania dotyczące przeglądu czasowego (w minutach) i krytycznego wykazały, że regularny trening sztuk walki może poprawić neuropoznanie i homeostazę neurohormonalną, przy czym główną przeszkodą jest ograniczona liczba badań w tym obszarze.

Wnioski. Dane z niniejszych badań sugerują, że trening sztuk walki w regularnym, powtarzalnym schemacie może obniżyć poziom kortyzolu i poprawiać wyniki neurotroficzne w postaci podwyższonego wydzielania BDNF. Wnioskowanie porównawcze i indywidualne w celu lepszego udowodnienia skuteczności form sztuki walki wymaga dalszych badań.