



Purpose in Life/Ikigai and Moderate Exercise may Prevent and Improve Violent Behavior: with Consideration of the Traits of Neurotransmitters and Hormones

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Author's contribution

*The only author performed the whole work. Author RI wrote the first draft of the paper.
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Review Article

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ABSTRACT

The prefrontal lobe, which is more evolved in humans compared to other mammals, has extensive connections with many other areas of the brain including the thalamus, hypothalamus, hippocampus, and amygdala. The prefrontal lobe functions include ambition, cognition, emotions, information evaluation, mental integration, voluntary activity, and organized response. Violent behavior is related to aggression, with less serotonin, gamma-aminobutyric acid interaction, more dopamine, and more testosterone. Violent behavior is reinforced by negative experiences including viewing of violence in childhood and successful problem solving by violence. Every person has a natural and intrinsic need to establish the meaning of life, relative to ambition. Purpose in life (PIL)/ikigai means an attitude to establish the meaning of life. The term PIL/ikigai has been commonly used in daily life for many years in Japan. PIL/ikigai contributes to a greater ability to cope with stress, i.e., greater pleasure and comfort as well as less anxiety and confusion during stressful situations. This process leads to increasing serotonin and decreasing testosterone. PIL/ikigai is reinforced by positive experiences, including being moved by persons and events, success in challenging events, spending time in beautiful natural surroundings, and warm-hearted human relations. Moderate aerobic exercise, e.g., walking and running, causes pleasure. This process results in improvement of the autonomic nervous system, i.e., optimal balance between the

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sympathetic nervous system and parasympathetic nervous system, and optimally balanced secretions of dopamine, β -endorphin, and serotonin. PIL/ikigai, performing aerobic exercise and violent behavior are prefrontal lobe functions. Prefrontal lobe function develops even during adulthood as the result of experiences. Thus, PIL/ikigai and moderate aerobic exercise may prevent and improve violent behavior.

Keywords: Purpose in life/ikigai; moderate aerobic exercise; violent behavior; prefrontal lobe function; neurotransmitters; hormones.

1. INTRODUCTION

Violent behavior, which is a worldwide issue, requires understanding, especially of the prefrontal lobe of the brain, which has an important role in the adaptation to changing environments. The prefrontal lobe, which is more evolved in humans compared to other mammals, has extensive connections with many other areas of the brain including the thalamus, hypothalamus, hippocampus, and amygdala [1,2]. The prefrontal lobe functions include ambition, cognition, emotion, information evaluation, mental integration, judgments and decisions, voluntary activities, and organized responses [1,2]. The prefrontal lobe function related to conscious regulation could have the ability for adaptation to changing environments in conjunction with the autonomic nervous system and endocrine system via neurotransmitters and hormones. This suggests that attitude, in continual response to persons, events, and social situations [3,4], could be a frontal lobe function. Additionally, experiences with either reward to be gained or pain to be avoided reinforce or change synaptic connections, structure, and function [2] even into adulthood [5]. The process provides the possibility of reinforcing or changing attitudes by altering the perception of experiences.

Stress causes negative emotions such as anxiety, tension, and confusion [1]. Negative responses to stress include aggression, dependency based on the need for approval from others, withdrawal and resignation, psychosomatic symptoms, and self-anesthetization with drugs and alcohol [1]. Excessive and continuous negative emotions caused by stress often lead to mental and somatic diseases such as depression and cardiovascular disease [6]. Positive responses to stress include achievement and constructive problem solving [1]. Variations in attitude depend on response, i.e., prefrontal lobe function [2]. The constant and continuous negative response of aggression is related to habitual violent behavior, which could be a prefrontal lobe function [1]. Violent behavior is related to lower levels of serotonin [7] and gamma-aminobutyric acid [8,9], and higher levels of dopamine [8,9] and testosterone [10]. Violent behavior is reinforced by negative experiences including the viewing of violence in childhood and repeated successful problem solving by violence [1]. Persons with habitual violent behavior may have mental and somatic diseases caused by excessive and continuous negative emotions [6,11]. Constant and continuous positive response of achievement and constructive problem solving is related to having a purpose in life (PIL) [12] and ikigai [13]. The concept of "purpose in life (PIL)" is drawn from existentialism [12,14-16] and "ikigai" appears in Japanese classical literature [17]; they are an attitude to establish the meaning of life [12,18] that could be a prefrontal lobe function. Collectively, PIL/ikigai commonly proposes that everything changes; life is a one-time experience, and every person has a need to establish the meaning of life [8,12,13]. The term PIL/ikigai has been commonly used in daily life for many years in Japan [18]. For example, "Growing vegetables and presenting them to neighbors with a smile is what makes my PIL/ikigai", and "The Great East Japan Earthquake in 2011 injured many people. However, many of them have

established a new PIL/ikigai". The intensity of PIL/ikigai can be measured by self-reported psychological instruments such as the "Purpose in Life Test (Ikigai Test)" [14,15]. PIL/ikigai develops by positive experiences, including being moved by persons and events, success in challenging events, spending time in beautiful natural surroundings, and warm-hearted human relations [19-23]. PIL/ikigai causes lower anxiety and confusion, has been shown to contribute to an optimal balance between the sympathetic nervous system and parasympathetic nervous system during experimental stressful situations such as the task of locating chips labeled with events by evaluation and integration according to one's PIL/ikigai [19-21,24] (Table 1). This could be related to the well-balanced secretion of neurotransmitters such as dopamine, [25,26], serotonin [27], and β -endorphin [28]. PIL/ikigai provides a lower risk of cardiovascular disease and lower mortality [18,29]. PIL/ikigai contributes to ambition, pleasure, and comfort with respect to others' viewpoints [12,13]. Many people, regardless of age and sex, perform habitual moderate aerobic exercise on roads and in gymnasiums in Japan. Moderate aerobic exercise, e.g., walking and endurance running, also improve the autonomic nervous function, i.e., the optimal balance between the sympathetic nervous system and parasympathetic nervous system [30-33] (Table 2) and increases serotonin and β -endorphin [34,35]. Therefore, violent behavior may be prevented and improved by PIL/ikigai and moderate aerobic exercise [2].

Table 1. Task of locating chips labeled with events by evaluation and integration according to one's PIL/ikigai [24]

Parameters	F-PIL group (n=36)	W-PIL group (n=31)	p
Change in scores reflecting confusion [‡] (during-before: points) [†]	5.92±11.84	12.19±12.07	*
Change in heart rate (after-before: beats/min) ^{† †}	8.78±6.09	12.00±7.19	+
Change in systolic blood pressure (after-before: mmHg) ^{† †}	4.89±7.30	5.10±7.09	0.367
Change in thumb-tip temperature (after-before: °C) ^{† †}	1.00±0.91	1.07±0.97	0.420

PIL: purpose in life; F-PIL: firm purpose in life; W-PIL: weak purpose in life; [‡]evaluated by the Profile of Mood States (POMS); [†]analysis of covariance; ^{† †}analysis of variance; *: $p < 0.05$; +: $p < 0.05/3 = 0.016$ after Bonferroni correction.

Table 2. Two aerobic exercise protocols for walking and running

Parameters	Protocol 1 [31]		p	Protocol 2 [32]		p
	Before training	After training		Before training	After training	
Subject						
n: male/female		4/8			5/5	
Years (means: total and male/female)		37.5±8.8			26.2±3.8 / 22.0±3.2	
Training						
Training sessions (days/week)		16 (2)			20 (2)	
Total energy expenditure during all sessions (Kcal: total and male/female)		1839.6			5756.4±408.3 / 5218.8±753.4	
Heart rate						
Before loading (beats/min)	69.9±10.1	62.5±10.5	*	63.5±9.2	61.3±6.3	
During loading (beats/min)	112.7±13.1	102.9±14.0	*	107.4±10.2	101.8±9.6	
After loading (beats/min)	73.9±11.3	65.4±11.7	*			
LF components						
Before loading	0.5±0.2	0.6±0.2		0.6±0.2	0.5±0.2	
During loading	0.6±0.2	0.5±0.2		0.6±0.1	0.4±0.2	*
After loading	0.6±0.2	0.6±0.2				
HF components						
Before loading	0.4±0.2	0.3±0.2		0.3±0.2	0.4±0.1	
During loading	0.4±0.1	0.4±0.1		0.3±0.1	0.4±0.1	*
After loading	0.3±0.1	0.4±0.2				
LF/HF						
Before loading	1.5±1.1	2.3±1.7		2.2±1.4	1.3±0.7	
During loading	2.2±2.1	1.5±1.1		1.9±0.9	1.1±0.9	*
After loading	2.2±1.6	2.4±2.4				
Blood analyses						
WBC ($\times 10^2/\mu\text{L}$)	48.5±4.4	49.3±4.4		60.8±30.3	56.1±16.7	
LYP ($\times 10^2/\mu\text{L}$)	16.9±1.7	15.4±1.7	*	20.5±6.1	20.2±6.7	
RBC ($\times 10^4/\mu\text{L}$)	430.9±35.9	421.4±35.6		478.2±52.1	451.8±55.4	**
HGB (g/dL)	12.8±0.9	12.8±1.0		14.5±1.9	13.8±2.1	*
HCT (%)	38.6±2.3	38.3±2.8		43.1±4.6	40.6±5.3	**

Data are means±standard deviation (SD). * $p < 0.05$; ** $p < 0.01$; n: number of subjects; WBC: white blood cell counts; LYP: lymphocyte; RBC: red blood cell counts; HGB: hemoglobin concentration; HCT: hematocrit; LF: low frequency components as the result of spectrum analysis of heart rate variability; HF: high frequency components; LF/HF: ratio of LF to HF.

2. VIOLENCE

Violent behavior caused by negative emotions such as aggression is related to prefrontal lobe function. This function involves interaction with other brain areas such as the amygdala and thalamus, and also causes an imbalance in the autonomic nervous system between the sympathetic nervous system and the parasympathetic nervous system via neurotransmitters and with the endocrine system via hormones. Dopamine, one of the neurotransmitters, is involved in motivation, reward, and reinforcement [25,26]. Noradrenaline influences sleep and wakefulness, attention, and feeding behavior [26]. β -Endorphin is involved in pleasure [26]. Oxytocin facilitates the recognition of familiar faces and trust in other people [2]. Serotonin is a major inhibitory neurotransmitter, a chemical that transmits electrical impulses in the brain from one neuron to another, causing better mood and comfort [1,7,27]. Gamma-aminobutyric acid is an inhibitory neurotransmitter [36]. The steroid hormone testosterone plays an important role in the regulation of social emotional behavior [10]. Testosterone influences the neural activity of specific portions of the brain, in particular the amygdala and ventral prefrontal areas [10,37]. Negative emotions such as anger, anxiety, tension, and confusion cause imbalanced secretion of neurotransmitters and hormones. Testosterone administration has been shown to increase amygdala responses to negative facial stimuli in middle-aged women [10,38]. Increased testosterone causes increased aggression [10]. A defect in serotonin processing in the brain results in impulsive or violent behavior [1,7]. Conversely, gamma-aminobutyric acid and serotonergic systems, which are associated with better mood, ameliorate aggressive and violent behaviors [8,9]. Furthermore, endogenous testosterone levels showed a negative correlation with activity in the orbital frontal cortex when participants received an unfair monetary offer [10,37]. Persons with lower testosterone levels generate larger ventrolateral prefrontal cortex and frontal pole activity while controlling social behavior [10].

Violent behavior develops by negative experiences including the viewing of violence in childhood [1]. Successful problem solving by violence [1], which is accompanied by pleasure and satisfaction, reinforces violence behavior [1]. Repeated failure in violent behavior accompanied by punishment from others decreases violent behavior [1]. This reinforcement process is related to the reward system via neurotransmitters such as dopamine [25,26]. This suggests that improvement of repeated experiences may change the neuronal network that influences attitude, and prevent and improve violent behavior.

3. PREVENTION OF VIOLENT BEHAVIOR

Attitude can change by repeated experiences accompanied by reward and punishment [1,2,39]. PIL/ikigai may be influenced by positive experiences and moderate aerobic exercise may prevent and improve violent behavior.

3.1 PIL/Ikigai

PIL/ikigai causes positive responses, e.g., less anxiety and greater comfort after feeling stress [18,22-24,29,40,41]. Violent behavior causes negative responses, e.g., aggression, after feeling stress [1]. Persons with PIL/ikigai have better prefrontal lobe function compared to those with violent behavior, leading to a greater ability to adapt to changing environments. Changing a person's attitude from violent behavior to PIL/ikigai contributes to preventing and improving violent behavior. This possibility of changing attitude is supported by the findings of previous studies, including: synaptic plasticity occurs even after adolescence [2,25];

ambition, comfort, and pleasure that comes from PIL/ikigai is related to dopamine [25,26], serotonin [27], and β -endorphin [28]; experiences, including learning and memory with reward and to avoid behaviors that cause pain, change synaptic connections, structure, and function [2]; gamma-aminobutyric acid and serotonergic systems ameliorate aggressive and violent behaviors [8,9]; and lower testosterone levels generate increased ventrolateral prefrontal cortex and frontal pole activities [10]. Positive experiences, including being moved by persons and events, success in challenging events, spending time in beautiful natural surroundings, and warm-hearted human relations, from infancy to adolescence [19-23] can change a person's attitude from violent behavior to PIL/ikigai. Examples include reading a biography, singing songs, seeing cultural heritage, fishing in rivers and seas, growing vegetables with friends, and helping people as a volunteer. This process indicates an improvement of the neuronal network influencing the response pattern to stimuli, i.e., stressful events.

3.2 Moderate Aerobic Exercise

Many studies dealing with aerobic exercise have proposed common results [30-33,42] (Table 2), including improvement of the autonomic nervous system, i.e., the relation between the sympathetic nervous system and the parasympathetic nervous system, as shown by decreased heart rate [31], blood pressure [43], red blood cell counts, hemoglobin concentration, and hematocrit [32,42]. The results also include increased serotonin level [27] and β -endorphin level [34,35]. These findings suggest that aerobic exercise as well as PIL/ikigai may contribute to improving the neuronal network that provides positive cognitive and emotional responses to changing environments. It should be noted, however, that excessive aerobic exercise causes increased production of reactive oxygen species, damaging cells and genes [44], and sports anemia that reduces the hemoglobin level [43]. Therefore, moderate aerobic exercise such as walking, running, and swimming should be planned with consideration of each individual's condition [43] including age, sex, and the surrounding environments.

3.3 Study Limitation

The proposals in this paper to prevent and improve violent behavior by using PIL/ikigai and moderate aerobic exercise are hypothetical based on previous studies dealing with prefrontal lobe function, neurotransmitters, and hormones. Not only PIL/ikigai and aerobic exercise, but also diet may affect neurotransmitters and hormones. Our studies dealt with experiences influencing PIL/ikigai only from infancy to adolescence, although prefrontal lobe function develops even after adolescence by repeated experiences [5,25]. Therefore, comprehensive and integrated studies should be performed.

4. CONCLUSION

The prefrontal lobe has been evolving for over 10,000 years and its function provides greater adaptability to changing environments. Having PIL/ikigai and performing moderate aerobic exercise are prefrontal lobe functions. Cannon [11] noted that "only by understanding the wisdom of the body, shall we attain that mastery of disease and pain which will enable us to relieve the burden of mankind". Thus, PIL/ikigai and moderate aerobic exercise, based on "the wisdom of the body", may improve the neuronal network, leading to the prevention and improvement of violent behavior.

CONSENT

Not applicable.

ETHICAL APPROVAL

Not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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