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뇌파를 이용한 생기능자기조절(뉴로피드백) 훈련에 대한 임상연구 동향 - 2000년부터 2013년까지 국내 학술지 논문을 중심으로 -

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The Review for Studies of Neurofeedback Training

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Objectives: The purpose of this study is to investigate the clinical trial research trends in regards to the neurofeedback training (NFT) in Korean journals.

Methods: We researched articles published in Korean journals from 2000 up to 2013 and were related to the NFT. We searched six electronic databases to find relevant articles, using the term 'neurofeedback'.

Results: 1) 6 single group comparative studies and 31 randomized controlled trials were found. 2) Healthy volunteers and students were most frequently studied with neurofeedback training. Other studies included attention deficit hyperactivity disorder (ADHD), Poststroke, panic disorder, premenstrual dysphoric disorder (PDD), temporomendibular disorder (TMD), and obesity. NFT interventions were attempted in diverse training protocols and assessed with many different outcome measurements. 3) Most studies showed effective results after NFT.

Conclusions: NFT is increasingly studied and used in various clinical fields. Also, there have been efforts to adopt NFT in Korean medical clinics and researches, and more rigorous and innovative studies are needed in the future.

Key Words: Neurofeedback Training, NFT, Korean Medicine, Clinical Trials.

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I. 서론

뇌파를 이용한 생기능자기조절(뉴로피드백) 훈련(이하 뉴로피드백 훈련)은 조작적 조건형성(operant conditioning) 이론에 근거하여 특정 뇌파를 강화하거나 억제시켜 뇌기능의 향상을 도모하는 훈련기법으로[1], 뇌의 전기적인 활동인 뇌파가 정신 상태를 반영하고 이러한 뇌파는 훈련으로 변화가 가능하다는 기본적 원칙에 근거를 두고 있으며, 자신의 뇌파를 실시간으로 검토하고 시각 및 청각적 되먹임을 받아 훈련자 스스로 뇌파를 의도하는 방향으로 조절하는 훈련이다[2].

뉴로피드백 훈련은 경련성 질환 치료를 위해 처음으로 사용된 이후[3], 알코올 의존 환자[4], 주의력결핍 과잉행동장애[5], 우울증, 불안장애[6], 수면장애[7], 뇌손상 환자의 인지저하의 치료[8]과 더불어, 정상인의 수행력 증가 목적[9] 등, 현재까지 뇌기능과 관련된 여러 증상과 다양한 분야에 걸쳐 활용되고 있다.

뉴로피드백 훈련은 기계장치를 이용하지만 불수의적 정신신체 상태를 조절한다는 측면에서 동양의 요가, 선, 기공, 명상 등과 목적 및 방법에서 공통점을 갖는다[10]. 또한 측정된 신체정보를 이용하여 정신 상태를 파악하여, 비정상적으로 증가된 뇌파를 낮추고 비정상적으로 감소된 뇌파를 강화하는 자기조절을 통해 치료하는 뉴로피드백 훈련은 심신일여(心身一如)의 인체관을 기반으로 음양의 균형과 조기치신(調氣治神)의 방법으로 건강을 유지하고 질병을 치료하는 한의학적인 접근과 많은 부분 유사하다[11].

뉴로피드백 훈련은 한의학적 치료 접근법과 공유하는 부분이 많아 앞으로 한의학 임상 현장에서 보다 많은 증상에 폭 넓게 응용될 것으로 예상되나, 관련된 국내 한의학계 연구는 주로 주의력결핍 과다행동장애[12,13], 뚜렛 장애[14], 진전[15], 울증[16], 사회공포증[17] 등에 뉴로피드백 훈련을 한방치료와 병행하여 적용한 증례보고에 치우쳐있으며, 임상연구로는 호흡명상과 함께 시행하여 정상 성인의 기억과 집중력에 미치는 영향[18]에 대한 단 하나의 보고만 있는 실정이다. 이에 본 연구에서는 한의학 분야에서의 뉴로피드백 훈련의 보다 체계적인 임상 활용 및 임상연구를 위한 기초자료를 마련하고자 국내 학술지에 발표된 뉴로피드백 훈련에 대한 기존 논문을 검색, 분석하여 연구 동향을 고찰하였다.

II. 연구대상 및 방법

2000년부터 2013년까지 국내학술지에 발표된 뇌파를 이용한 생기능자기조절(뉴로피드백) 훈련에 대한 임상연구 논문들을 대상으로 하여 검색하였으며, 발표초록이나 업적집, 학술대회 발표 등은 배제하였다.

논문의 검색은 학술논문 검색 데이터베이스인 DBpia (http://www.dbpia.co.kr/), 학술 데이터베이스인 KISS (http://kiss.kstudy.com/), 학술정보 검색 데이터베이스인 과학기술학회마을(http://society.kisti.re.kr/main.html), 한국교육학술정보원(KERIS)에서 제공하는 RISS (http://

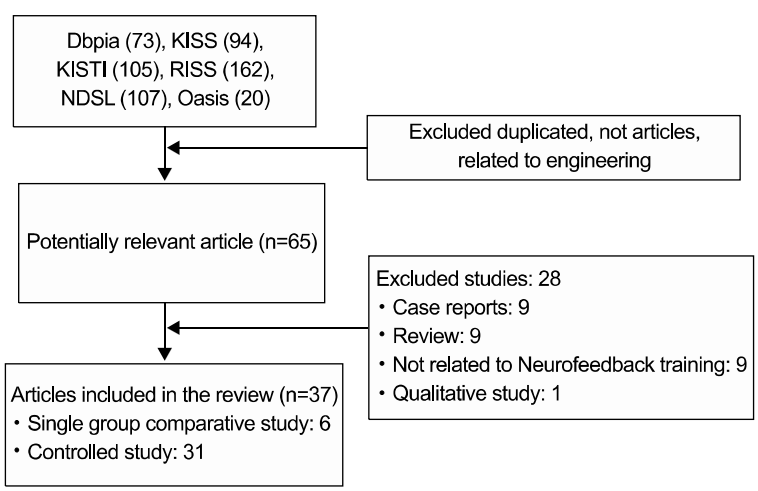

Fig. 1. Flow diagram preferred reporting items for review.

www,riss. kr/ index.do), 한국과학기술정보연구원에서 제공하는 국가과학기술정보센터 NDSL (http://www.ndsl.kr/index.do), 한국한의학연구원에서 제공하는 전통의학포털시스템 OASIS (http://oasis.kiom.re.kr/main.jsp)을 활용하였으며 'neurofeedback', '뉴로피드백'을 검색어로 사용하였다.

III. 결과

검색한 결과 DBpia에서 73편, KISS에서 94편, 과학기술학회마을에서 105편, RISS에서 162편, NDSL에서 107편, 오아시스에서 20편이 검색되었다 이 중 검사결과에 중복이 되는 것, 발표초록, 업적집, 학술대회, 기사, 공학논문, 원문을 확인할 수 없는 논문 등을 제외한 65편 중, 종설논문 9편, 증례보고 9편, 질적 연구 1편, 뉴로피드백 훈련에 대한 연구가 아닌 9편을 제외하고 총 37편을 선정하였다(Fig. 1).

37편의 논문 중 단일군 연구가 6편, 뉴로피드백 훈련과 다른 치료를 병행하거나 다른 치료와 비교한 연구가 8편이었고, 가짜 뉴로피드백 훈련을 실시한 대조군 연구는 2편이었다. 검색된 37편의 연구대상, 처치방법, 평가기준, 결과 등을 정리, 분석하였다(Table 1).

1. 연구의 질 평가

37편의 논문 중 무작위배정을 시행한다고 표현한 논문은 16편이었으며 1편의 논문에서 번호 뽑기를 시행하여 무작위배정을 시행하였다고 언급하였다. 9편의 논문에서 탈락과 중도 포기를 기재하였으며, 모든 논문에서 이중 맹검을 시행하지 않았다. Jadad Quality Assessment Scale 점수는 4편의 논문이 2점이고 나머지는 모두 1점 이하로 대체로 논문의 질이 낮았다.

2. 연구대상 및 질환

전체 임상연구 중 특정 질환이나 증상을 호소하지 않는 비질병인을 연구대상으로 한 논문 중 대학생 혹은 대학원생을 대상으로 한 연구가 4편, 초, 중, 고등학생을 대상으로 한 연구는 10편, 유치원생을 대상으로 한 연구는 6편, 성인이 대상인 연구는 3편, 청각장애학생 대상 연구 2편, 장기요양시설 노인, 골프선수, 바둑기사를 대상으로 한 연구가 각각 1편이었다.

특정 질환이나 증상에 대한 연구는 9편으로, 주의력결핍과잉행동장애 혹은 학습능력저하 및 주의력 저하를 호소하는 아동을 대상으로 한 연구가 3편, 만성 뇌졸중 환자를 대상으로 한 연구가 2편, 공황장애, 월경 전 불쾌장애, 측두하악장애, 비만 환자를 대상으로 한 연구가 각각 1편이었다.

3. 치료

1) 단독 치료

임상연구논문에서 실험 처치에 뉴로피드백 훈련만이 시행된 단독치료 연구는 단일군 연구를 포함하여 모두 29편이었다.

2) 병용 치료

뉴로피드백 훈련과 함께 다른 치료가 함께 시행된 병용치료 연구로는 두개천골요법을 결합한 연구가 2편, 근력강화 트레이닝, 호흡명상, 약물치료, 재활치료를 결합한 연구가 각각 1편이었다.

뉴로피드백 훈련과 다른 치료방법의 효과를 비교한 연구 중 뉴로피드백 훈련과 두개천골요법을 비교한 연구가 2편, 뉴로피드백 훈련과 뇌교육을 비교한 연구가 2편, 뉴로피드백 훈련과 약물치료를, 뉴로피드백 훈련과 컴퓨터보조 인지재활 훈련을 비교한 연구가 각각 1편이었다.

4. 뉴로피드백 훈련 모드

뉴로피드백 훈련 모드는 연구 목적 및 질환에 따라 다양하였다. 2편의 논문에서는 뉴로피드백 훈련 방법에 대한 기술이 없었고, 16편의 논문에서는 훈련 모드를 훈련 전 뇌파 측정을 하여 훈련자의 전전두엽 뇌파의 상태에 따라 결정하도록 하였다. 훈련모드로는 측두하악장애, 뇌졸중 후유증 환자, 주의력 저하 아동, 골프 선수를 연구대상으로 하는 4편의 연구에서 beta-SMR 모드를, 공황장애, 뇌졸중 후유증, 비만환자를 연구대상으로 하는 3편의 연구에서 bata-SMR 모드와 alpha-theta 모드를 함께 사용하였다.

Alpha 파 강화 훈련을 한 연구는 2편으로 사격선수의 사격 수행력과 초등학생의 재인, 회상 기억 향상에 대한 연구였다. 그 밖에 월경 전 불쾌장애 환자를 대상으로 전두엽 Alpha 파 대칭성 훈련을 한 연구가 1편, 호흡명상과 함께 두뇌이완훈련, 집중력 훈련, 좌우뇌 균형 훈련을 시행한 연

Table 1. Summary of Treating Neurofeedback Training in Clinical Trials

Author (year)	Subjects (M/F)	Sample size	Treatment Duration	Assessment Outcome measurement	Results	Training mode
Children with attention deficit, degradation of learning ability, ADHD						
Sin KS[19] (2009)	5~12 years old children (12/8) K-ARS score over 7 or ADDES - HV inattention score over19	20	NFT 30 min. 2~3 times/week 20 sessions	K-ARS, ADDES - HV	The subscale of mean inattention and impulsivity/ hyperactivity score of ARS was reduced significantly. The subscale of inattention, impulsivity, and hyperactivity scores of ADDES-HV were reduced significantly.	Beta-SMR mode
Bak KJ[20] (2007)	Primary students showing degradation of learning ability, attention deficit, psychological problems (25/25)	25 25	(A) NFT 40~60 min. 2~3 times/week over 30 sessions (B) Control waiting	Brain function quotient: SRQ, ATQ, ASQ POMS The Amen Clinic ADD type Questionnaire (Healing ADD)	The ATQ and ASQ were significantly increased in (A) group. The mood state was significantly improved, and attention-deficit characteristics was significantly decreased in (A) group.	Setup depending on the EEG state Relaxation, concentration, attention training
Roh OB[21] (2011)	ADHD children	11 9 9	(A) NFT 30 min. 2~3 times/week 20 sessions (B) NFT+Medication (C) Medication	K-ARS	The inattention score of (A) group significantly decreased more than that of the medication group.	· Inattention subtype—enhancing β wave training · Hyperactivity/impulsivity subtype—enhancing SMR wave training · Mixed subtype—enhancing β wave training+enhancing SMR wave training
Chronic stroke patients						
Lee YS[22] (2013)	Chronic stroke patients with hemiparalysis MMSE-K score 14~23	10 10	(A) NFT 30 min. 5 times/week 4 weeks (B) Control waiting	Brain wave activity: QEEG-8 (Laxtha3208, Laxtha Inc., Korea) Stroop test, MMSE-K, DST	Absolute α-power of (A) group increased and absolute θ-power decreased significantly compared to (B) group. The MMSE-K score of (A) group has increased significantly, and the error in Stroop Test and DST in (A) has decreased significantly compared to (B) group.	Beta-SMR mode and alpha-theta mode
Jung MW[23] (2012)	Patients with stroke hemiparalysiswithin 3 months 1 year under 24 score MMSE-K	14 14 16	(A) Conventional rehabilitation training + NFT 30 min. 5 times/week 6 weeks (B) Conventional rehabilitation training + Computer Assisted Cognitive Rehabilitation 30 min. 5 times/week 6 weeks (B) Conventional rehabilitation training 30 min. 5 times/week 6 weeks	MMSE-K MFT	MMSE-K score was increased significantly in all three groups, but there was no statistically significant difference among groups. Total NFT score was increased significantly in all three groups, but there was no statistically significant difference among groups.	Beta-SMR mode

NFT: Neurofeedback training, K-ARS: Korean-Attention-Deficit/Hyperactivity Disorder Rating Scale, ADDES-HV: Attention Deficit Disorder Evaluation Scale - Home Version, SRQ: Self Regulation Quotient, ATQ: Attention Quotient, ASQ: Anti-stress Quotient, POMS: Profile of Mood state, ADHD: Attention Deficit/Hyperactivity Disorder, DST: Digit Span Test, MMSE-K: Mini-Mental State Examination-Korea, MFT: Manual Function Test, K-APPQ: Korean Albany Panic and Phobia Questionnaire, PMDD: Premenstrual Dysphoric Disorder, SPAF: Shortened Premenstrual Assessment Form, TMD: Temporomandibular Disorder, PSQI: Pittsburgh Sleep Quality Index, OHIP-14: Oral Health Impact Profile, BRQ: Basic Rhythm Quotient, ACQ: Activity Quotient, EQ: Emotion Quotient, CQ: Corelation Quotient, BQ: Brain Quotient, BIS/BAS: the Behavioral Inhibition System/Behavioral Activation System scale, TTCT; Torrance Tests of Creative Thinking, VAS: Visual Analog Scale, DHQ: Daily Hassles Questionnaire, SF-36: 36-Item Short-Form Health Survey, AMPQ: Adolescent Mental Problem Questionnaire, K-WAIS: Korean Wechsler Adult Intelligence, HRSD : Hamilton Rating Scale for Depression, STAI: State - Trait Anxiety Inventory, BDI: Beck Depression Inventory, HRV: Heart Rate Variability, K-ABC: Kaufman Assessment for Children, K-WPPSI: Korean Wechsler Preschool and Primary Scale of Intelligence, K-Raven CPM: K-Raven CPM (coloured progressive matrices), MIDAS-MYC: Korean Multiple Intelligence Development Assessment Scale-My Young Child, BDNF: Brain Derived Neurotropic Factor, NGF: Nerve Growth Factor.

Table 1. Continued 1

Author (year)	Subjects (M/F)	Sample size	Treatment Duration	Assessment Outcome measurement	Results	Training mode
Panic disorder, obese womwen, PMDD, TMD						
Kang SW[24] (2006)	Panic disorder, refractory to cognitive-behavioral therapy and medication (3/3)	6	NFT 1 hour 3 times/week 20 sessions	K-APPQ	The score of total K-APPQ, agrophobia, and interoceptive fear were significantly deceased after NFT.	Beta-SMR mode+alpha-theta mode
Rhee SY[25] (2007)	Obese Korean women (BMI over 25 kg/m^2) who failed to 12 week medical nutritional therapy (0/15)	15	NFT 30~60 min. 1 time/week 8 sessions	Anthropometry Biochemical analysis Eating pattern analysis Diet quality index Food intake behavior	Total body fat, body fat percentage and fasting plasma glucose were significantly decreased, and insulin concentration were significantly increased after neurofeedback intervention. The energy from carbohydrate intake were significantly decreased after neurofeedback intervention. The scores of cognitions about dietary method and regularity were significantly decreased after neurofeedback intervention.	Beta-SMR mode+alpha-theta mode
Oh EH[26] (2009)	Unmarried women with PMDD (0/16)	8 8	(A) NFT 24 min. 2 times/visit 20 sessions (B) Control waiting	SPAF	The score of affective, behavioral and physical symptoms of (A) group were reduced significantly compared to (B) group.	Alpha symmetry training
Park JH[27] (2011)	TMD (0/14)	7 7	(A) NFT 30 min. 2 times/visit, 20 sessions (B) Control waiting	Jaw pain: VAS PSQI OHIP-14	VAS of jaw pain was significantly decreased (A) group more than (B) group. The score of PSQI was significantly decreased (A) group more than (B) group. The score of OHIP-14 was significantly improved (A) group more than (B) group.	Beta-SMR mode
Undergraduate and graduate students						
Kum MH[28] (2012)	Nursing students	121	NFT 30 min. 2 times/week 10 weeks	Brain function quotient: SRQ, BRQ, ATQ, ACQ, EQ, ASQ, CQ, BQ	SRQ, ATQ, ACQ, EQ, ASQ, BQ were significantly increased after the NFT.	Setup depending on the EEG state Relaxation, concentration, attention training
Chi YK[29] (2009)	Right - handed under graduate and graduate students (0/17)	9 8	(A) NFT to increase the left frontal activity 4 min. 5 times/day 15 sessions (A) NFT to increase the right frontal activity 4 min. 5 times/day 15 sessions	BIS/BAS Responses to emotionally evocative film clips	BAS score of (A) group was significantly higher BAS score than (B) group. The emotional responses to obvious emotional film clips of (A) group were stronger than that of (B) group.	(A) Inhibiting alpha wave activity of the left frontal lobe (B) Inhibiting alpha wave activity of the right frontal lobe
Song YS[30] (2007)	Nursing students (0/36)	18 18	(A) NFT 30 min. 3 sessions/week 6 weeks (B) Control waiting	TTCT	The scores of flexibility and creativity were increased significantly in (A) group compared to (B) group.	Alpha symmetry training Creativity training Mind piece game

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Table 1. Continued 2

Author (year)	Subjects (M/F)	Sample size	Treatment Duration	Assessment Outcome measurement	Results	Training mode
Song YS[31] (2006)	Nursing students	18	(A) NFT 30 min. 3 sessions/week 6 weeks	perceived fatigue: VAS perceived stress: VAS	Perceived fatigue and perceived stress were decreased significantly in (A) group.	Breathing Concentration training
		18	(B) Control waiting	Lymphocyte (n/ μl)% of NK cell	The number of lymphocyte was increased significantly in (A) group.	Attention training
Primary, middle, high school students						
Ahn SK[32] (2009)	Primary students (28/20)	24	(A) NFT 40 min. 3 times/week	Brain function quotient: ASQ, Body stress index, Mental stress index	ASQ were increased significantly and body stress and metal stress indexes were decreased significantly in (A) group.	Setup depending on the EEG state Relaxation, concentration, attention training
		24	(B) Control waiting	Academic achievement	The scholastic achievement/competence were increased significantly and anxiety was decreased in (A) group.	
Weon HW[33] (2008)	High school students (62/0)	29	(A) NFT 30 min. 3 times/week 12 weeks	Brain function quotient: BRQ, SRQ, ATQ, ACQ, EQ, ASQ, CQ, BQ	SRQ, ATQ, ACQ, CQ, and BQ were increased significantly in (A) group compared to (B) group.	Setup depending on the EEG state Relaxation, concentration, attention training
		33	(B) Control waiting	DHQ	The score of total stress, friend stress, family stress and school stress were decreased significantly in (A) group compared to (B) group.	
Weon HW[34] (2013)	High school students (0/11)	5	(A) NFT 40 min. 2 times/week 20 sesseions	SF-36 AMPQ	ASQ, and EQ were significantly increased in (A) group compared to (B) group.	Setup depending on the EEG state Relaxation, concentration, attention training
		6	(B) Control waiting	Brain function quotient: SRQ, ATQ, ACQ, EQ, ASQ, CQ, BQ		
Ahn SK[35] (2011)	Middle school students (32/28)	30	(A) NFT 40~60 min. 2~3 times/week over 40 sessions	Brain function quotient: SRQ Self-directed learning ability	SRQ was significantly increased in (A) group compared to (B) group. Self-directed learning ability score was statistic increased significantly in (A) group compared to (B) group.	Setup depending on the EEG state Relaxation, concentration, attention training
		30	(B) Control waiting			
Ahn SK[36] (2010)	Primary school students	26	(A) NFT 40 min. 2~3 times/week over 30 sessions	Brain function quotient: SRQ, training protocol, maximum deviation	SRQ and training protocol were significantly increased in (A) group compared to (B) group, and maximum deviation were significantly decreased in (A) group compared to (B) group.	Setup depending on the EEG state Relaxation, concentration, attention training
		26	(B) Control waiting	Self-directed learning ability	The score of self regulation ability were significantly increased in (A) group after neurorfeedback training.	
Ahn SK[37] (2011)	Primary school students (25/25)	25	(A) NFT 40~60 min. 2~3 times/week, over 40 sessions	Brain function quotient: ATQ, BQ School achievement motivation	Brain function quotient were statistic significantly increased (A) group compared to (B) group. The score of school achievement motivation was statistic significantly increased (A) group compared to (B) group.	Setup depending on the EEG state Relaxation, concentration, attention training
		25	(B) Control waiting			

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Table 1. Continued 3

Author (year)	Subjects (M/F)	Sample size	Treatment Duration	Assessment Outcome measurement	Results	Training mode
Byun YE[38] (2011)	Primary, middle, high school students (18/27)	18 27	NFT Male group 25~30 min. 2~3 times/week 20~25 sessions NFT Female group 25~30 min. 2~3 times/week 20~25 sessions	Brain function quotient: BRQ, SRQ, ATQ, ACQ, EQ, ASQ, CQ, BQ	Primary students: SRQ was significantly increased in (A) group. ATQ, ACQ, ASQ, and BQ were significantly increased in (B) group. Middle school students: ATQ, ASQ, and BQ were significantly increased in (A) group. ATQ, ACQ, and BQ were significantly increased in (B) group. High school students: ACQ, ASQ) were significantly increased in (A) group. ATQ, EQ, BQ were significantly increased in (B) group.	Not described
Byun YE[39] (2011)	Primary, middle,high school students (18/27)	45 45	(A) NFT 25~30 min. 2~3 times/week 20~25 sessions (B) Control waiting	Brain function quotient: BRQ, SRQ, ATQ, ACQ, EQ, ASQ, CQ, BQ	Primary students: SRQ, ATQ, ACQ, ASQ, and BQ were significantly increased in (A) group after NFT. Middle school students: SRQ, ATQ, EQ, ASQ, and BQ were significantly increased in (A) group after NFT. High school students: ATQ, ACQ, EQ, and BQ were significantly increased in (A) group after NFT.	Not described
Yang HR[40] (2010)	4th year primary students (21/15)	18 18	(A) NFT 30 min, 2 times/week 4 sessions (B) Control sham NFT	Training performance Recall memory Recognition memory	The scores of training performance of (A) group were enhanced as the training session progressed. The overall scores of recall and recognition performance of (A) group were enhanced by the administration of the training itself and as the training sessions advanced compared to (B) group.	Enhancing alpha wave
Adults						
Chung SY[18] (2008)	Healthy adult volunteers (12/13)	13 12	(A) breath meditation with NFT 15 min. 3 times/week 10 sessions (B) breath meditation with sham NFT 15 min. 3 times/week 10 sessions	Cognitive functions assessment K-WAIS, HRSD, STAI, BDI VAS about amnesia, HRV	Concentration, and cognition strength were increased significantly in (B) group compared to (A) group.	Relaxation training Concentration training Alpha symmetry training

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Table 1. Continued 4

Author (year)	Subjects (M/F)	Sample size	Treatment Duration	Assessment Outcome measurement	Results	Training mode
Lee JE[41] (2010)	Middle aged women (0/71)	17	(A) NFT 30 min. 3 times/week,10 sessions	Subjective symptoms of fatigue	There were no significant differences among all groups on the score of perceived fatigue and stress.	Setup depending on the EEG state
		17	(B) Cranio-sacral therapy 60 min. 1 time/week,10 sessions	Perceived stress	There were no significant differences among (A), (B), (C) groups on brain function quotients.	Relaxation, concentration, attention training
		19	(C) NFT + Cranio-sacral therapy	Brain function quotient: ATQ, Body stress index ASQ, EQ, BQ		
		18	(D) Control Health counselling 4 sessions			
Lee JE[42] (2008)	Middle aged women (0/71)	17	(A) NFT 30 min. 3 times/week 30 sessions	Brain function quotient: ATQ, ASQ	There were no significant differences among (A), (B), (C) groups.	Setup depending on the EEG state
		17	(B) Cranio-sacral therapy 60 min. 1 time/week 10 sessions			Relaxation, concentration, attention training
		18	(C) NFT + Cranio-sacral therapy			
		19	(D) Control waiting			
Kindergarten kids						
Bak KJ[43] (2009)	Kindergarten kids (31/17)	24	(A) NFT 30 min. 2 times/week	Brain function quotient: CQ (symmetry, corelation)	The corelation was significantly increased in (A) group.	Setup depending on the EEG state
		24	(B) Control waiting			Relaxation, concentration, attention training
Bak KJ[44] (2010)	Kindergarten children (27/13)	20	(A) NFT 30 min. 2 times/week	Brain function quotient: ASQ, body stress index , mental stress index	ASQ were significantly increased in (A) group compared to (B) group.	Setup depending on the EEG state
		20	(B) Control waiting		The indexes of body stress, mental stress were significantly decreased in (A) group compared to (B) group.	Relaxation, concentration, attention training
Bak KJ[45] (2011)	Kindergarten children (31/22)	26	(A) NFT 30 min. 2 times/week	Brain function quotient: AQ, ASQ, CQ K-ABC	ATQ, CQ were increased significantly in (A) groups compared to (B) group.	Setup depending on the EEG state
		26	(B) Control waiting		The score of master ability was increased in (A) groups compared to (B) group after NFT.	Relaxation, concentration, attention training
Jang SO[46] (2009)	5-years-old Kindergarten children (31/29)	30	(A) NFT 25 min. 3 times/week, 90 sessions	Brain function quotient: BQ, BRQ, SRQ, ATQ, ACQ, EQ, ASQ, CQ K-WPPSI	BQ, SRQ, ATQ, ACQ, EQ, ASQ, CQ were significantly increased in (A) group after neufeedback training.	Setup depending on the EEG state
		30	(B) Control waiting		The total IQ score and performance intelligence quotient score were significantly increased in (A) group.	Relaxation, concentration, attention training

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Table 1. Continued 5

Author (year)	Subjects (M/F)	Sample size	Treatment Duration	Assessment Outcome measurement	Results	Training mode
Cho SJ[47] (2012)	5-years-old Kindergarten children	30	(A) Brain education 20 min. 2 times/week, 12 weeks	K-Raven CPM MIDAS-MYC	All sub-factors of thinking ability were significantly improved in (B) group compared to other groups. All sub-factors of multiple intelligence were significantly improved in (A) group compared to other groups	Breathing Relaxation & tension training Corelation training
		30	(B) NFT 20 min. 2 times/week, 12 weeks			
		30	(C) Control waiting			
Cho SJ[48] (2011)	5-years-old kindergarten children	30	(A) Brain education 20 min. 2 times/week, 12 weeks	Brain function quotient: BRQ, SRQ, ATQ, ACQ, EQ, ASQ, CQ K-Raven CPM MIDAS-MYC	NFT had no great difference from control group in the side of strengthening correlation among multiple intelligence, thinking power, and sub-factors of braining functions. Brain education training strengthened correlations with multiple intelligence, thinking power, and correlations between sub-factors of braining functions.	Breathing Relaxation & tension training Corelation training
		30	(B) NFT 20 min. 2 times/week, 12 weeks			
		30	(C) Control waiting			
The elderly						
Youn MK[49] (2012)	The elderly with long-term care insurance service	5	(A) NFT 30 min. 3 times/week 60 sessions	Brain function quotient: ATQ, ASQ, EQ, BQ	Brain function quotient were increased significantly in (A) group compared to (B) group.	Setup depending on the EEG state Relaxation, concentration, attention training
		6	(B) Control waiting			
The hearing impairments						
Bak KJ[50] (2010)	The hearing impairments students (8/8)	16	NFT 40 min. 2 times/week	Brain function quotient: ASQ, body stress index, mental stress index	ASQ were significantly increased) and the body stress and mental stress indexes were significantly decreased.	Relaxation, concentration, attention training
Bak KJ[51] (2011)	The hearing impairments students (21/18)	25	(A) NFT 40 min. 2 times/week 9 months	Brain function quotient: ASQ, ATQ POMS	Brain function quotient were statistic significantly increased (A) group compared to (B) group. The mood state of (A) group was improved significantly after NFT.	Relaxation, concentration, attention training
		14	(B) Control waiting			
Athletes						
Park JS[52] (2005)	High school shooting players (6/0)	6	NFT 20 min. 6 times/week, 3 weeks	10.5% aiming rate: coaching machine (Shooter training system, Russia)	10.5% aiming rate during NFT was significantly better than that before NFT.	Enhancing alpha wave
Bak KJ[53] (2008)	Baduk players (30/0)	15	(A) NFT 20~30 min. 3 times/week 30 sessions	Brain function quotient: ATQ ,EQ, ASQ Baduk strength	Brain function quotient in (A) gruop were increased significantly after the NFT Baduk strength of (A) gruop after the neurofeedback was significantly bigger than (B) group.	Setup depending on the EEG state Relaxation, concentration, attention training
		15	(B) Control waiting			
Kim JS[54] (2013)	Collegiate golf athletes (30/0)	10	(A) Muscular strength 90 min. 3 times/week 12 weeks	BDNF, NGF Competition ability	BDNF was significantly increased in (B) group than other groups. Competition ability was not significant difference between groups.	Beta-SMR mode
		10	(B) Muscular strength + NFT 1 hour8 2 times /week 12 weeks			
		10	(C) Control waiting			

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구가 1편, 전두엽 Alpha 파 비대칭성이 동기에 미치는 영향에 대한 연구가 1편, 주의력결핍 과잉행동장애 아동의 아형에 따라 서로 다른 뇌파 대역을 강화한 연구가 1편이었다. 그 외 6편의 논문에서는 뉴로피드백 훈련 프로그램에 있는 훈련 방법과 훈련 게임에 대해 기술하였다.

훈련 횟수나 기간을 정확히 기재하지 않은 연구가 9편이었으며, 회기 당 훈련시간은 최소 15분에서 최대 60분, 훈련기간은 최소 3일부터 최대 9개월, 훈련횟수는 최소 4회기에서 최대 90회기, 훈련 빈도는 연구마다 1일 1회부터 주당 1회까지 다양했다.

5. 평가도구

임상연구 중 가장 많이 사용된 평가척도는 뇌기능지수(Brain Function Quotient)로 뇌기능지수를 평가도구로 사용된 연구는 21편이었으며 그 중 뇌기능지수만을 평가도구로 사용한 연구가 6편이었다.

뇌기능 지수 외 다양한 설문검사 및 신체검사가 시행되었다. 주로 시행된 설문검사는 한국판 간이정신상태 검사(Mini-Mental State Examination - Korea; MMSE-K), 한국판 주의력 결핍 및 과잉행동장애 평가척도 - 부모용(Korean-Attention-Deficit/Hyperactivity Disorder Rating Scale; K-ARS), 기분상태 설문지(Profile of Mood state; POMS), 색채누진행렬 지능검사(K-Raven CPM [coloured progressive matrices]; K-Raven CPM), 교사용 유아 다중지능 평가검사지(Korean Multiple Intelligence Development Assessment Scale-My Young Child; MIDAS-MYC), 자기주도학습 능력 설문지(Self-directed learning ability questionnaire) 2편이었으며, 대상 질환 및 평가대상에 따라 스트레스 척도, 피로 척도, 삶의 질 척도, 우울척도, 불안척도 불면척도, 공황장애 척도, 증상에 대한 시각화 척도, 지능검사 등이 사용되었다.

객관적인 신체검사로는 신경가소성 예측인자(BDNF, NGF), 심박변이도, 면역세포, 신체계측, 혈액 생화학적 분석이 사용되었다.

IV. 고찰

본 연구에서는 국내 학술지에 발표된 뉴로피드백 훈련을 시행한 임상연구를 선별하여 그 결과를 분석하였다. 국내 데이터베이스에서 본 연구 목표에 합당한 연구 37편을 선정하였으며, 이중 단독 치료(뉴로피드백 훈련)군과 대기군을 대조군으로 하여 비교한 연구가 23편으로 가장 많았으며, 단일군 전후 비교 연구 6편, 병행치료(뉴로피드백 훈련군과 다른 치료를 결합)를 실시하거나 다른 치료군과 비교한 연구가 8편이었다.

선정된 임상 연구 논문 중 뉴로피드백 훈련 시행 전후 비교 연구와 대기군을 대조군으로 한 연구에서는 모두 뉴로피드백 훈련이 유의한 효과를 보인다고 보고하였다. 뉴로피드백 훈련을 시행한 결과, 공황장애 증상의 호전, 월경 전 불쾌감 증상 감소, 주의력결핍 및 과잉행동 충동성 척도 점수 감소, 비만 환자에서의 체지방량 감소와 식사행동의 변화, 주의력 상승, 좌우뇌 균형 상승, 창의력 척도 점수 상승, 피로, 스트레스 척도 점수 감소, 면역력이 증가하고, 뇌기능 지수의 개선이 보이고 각종 정서, 건강척도, 뇌파활성화, 인지기능척도상승, 자기주도 학습능력, 통증, 수면 질, 삶의 척도 개선, 바둑수행력, 사격수행력 상승이 나타났다[19-22,24-27,29-39,43-46,49-52].

가짜 뉴로피드백 훈련을 대조군으로 한 논문이 2편 있었는데 대조군의 피험자에게는 뇌파 상태와 무관하게 무선으로 변화하는 시각적 자극을 제시하였다[18,40]. 호흡명상과 뉴로피드백 훈련을 병행한 연구[18]에서는 가짜 뉴로피드백 훈련을 시행한 대조군에서 집중력과 인지강도에서 유의한 향상을 보였으며, 초등학생을 대상으로 뉴로피드백 훈련 후 회상기억과 재인기억 수행 변화를 관찰연구[40]에서는 뉴로피드백 훈련 집단이 유의하게 우수한 수행결과를 보였다.

또한 뉴로피드백 훈련과 다른 치료방법을 병행하거나 다른 치료방법과 비교한 8편의 연구[18,21,23,41,42,47,48,54] 중, 근력복합트레이닝과 뉴로피드백 훈련을 함께 한 실험군의 혈중 BDNF 수치가 근력복합트레이닝 훈련군보다 유의하게 높았으며[54], 주의력결핍 과잉행동장애 아동의 부주의와 과잉행동/충동성 점수는 뉴로피드백 훈련 집단에서 약물치료 집단에서보다 유의하게 감소되었다[21]. 그러나 다른 6편의 연구에서 뉴로피드백 훈련은 다른 치료방법과 효과면에서 유의한 차이를 보이지 않았다.

뉴로피드백 훈련 후 긍정적 효과가 보고된 논문은 대부분 훈련 전후비교 연구나, 대기군을 대조군으로 한 연구였다. 가짜 뉴로피드백 훈련을 대조군으로 한 연구와 뉴로피드백 훈련과 다른 치료를 비교한 연구들의 결과가 일관되게 나타나지 않아 Fuchs 등의 연구[55]에서 제기된 바와 같이 뉴로피

드백 훈련의 플라시보 효과에 대한 가능성이 어느 정도 인정된다고 할 수 있다. 또한, 보고된 긍정적 효과가 뉴로피드백 훈련에 의한 것만이 아니라 훈련자의 의무감, 새로운 치료법에 대한 기대감, 치료사에 대한 신뢰, 기타 생활 변화 등이 모두 반영된 결과일 수도 있다. 향후 피험자의 기대와 같은 사회심리학적 요소가 뉴로피드백 훈련의 치료효과에 공헌하는 측면, 다른 치료 방법과 구분되는 뉴로피드백 훈련이 갖는 차별적인 효과에 대해서 연구가 이루어져야 할 것으로 사료된다.

본 연구는 뉴로피드백 훈련을 다양한 질환과 대상에 적용한 연구결과를 모두 취합하였기 때문에 다양한 훈련방법과 평가도구가 사용되었다. Bata-SMR 모드를 사용한 연구가 4편, bata-SMR 모드와 alpha-theta 모드를 사용한 연구는 3편, Alpha 파 강화 훈련을 시행한 연구 2편, 전두엽 Alpha 파 대칭성 훈련을 한 연구가 1편, 전두엽 Alpha 파의 비대칭성을 유도한 훈련을 한 연구가 1편이었고, 두뇌이완훈련, 집중력훈련, 알파파의 전두엽에서의 좌우 균형훈련을 사용한 연구가 1편이었다. ADHD 아동을 대상으로 한 연구에서는 연구대상자의 증상에 따라 훈련모드를 달리하였고, 그 외 15편의 연구에서 훈련 전 피험자의 자기조절능력을 분석 후 피검자가 피드백한 뇌파 중 상대적 비율이 낮은 주파수를 피검자의 훈련모드로 선택하였다.

뇌 영역에 따라 출현하는 뇌파가 다르고 특정 활동에 따라 주된 활동을 보이는 뇌파가 다르므로, 훈련자가 뉴로피드백 훈련으로 활성화하거나 억제하려는 뇌파는 관련 질환과 연구목적에 따라 차이를 지니게 된다[56]. 대표적인 뉴로피드백 훈련모드 중 bata-SMR 모드는 집중력 장애, 불안, 우울, 간질, 통증, 뇌졸중 등 두뇌손상 후유증 등의 치료에 주로 이용하며[57], 체성감각을 억제시켜 근육의 긴장도를 낮추고[58], 수면의 질을 개선시킨다는 보고가 있다[59].

Alpha-theta 모드는 편도를 포함한 변연계를 안정화시키는 효과가 있는 것으로 알려져 있으며 대개 무의식 영역에서 기원하는 공포증, 외상 후 스트레스 장애 등의 증상치료 및 치유되지 않는 감정적 기억의 완화, 깊은 명상의 유도 등을 위해 사용된다[57,60]. 전두엽 비대칭은 정서와 밀접한 관련이 있어 우울증 환자에게서 전두엽에서의 알파파의 비대칭이 우울증 환자에게서 나타나고[61], 좌반구 전전두엽은 접근체계로서의 욕구 행동 및 긍정적 정서를 발생시키고 우반구 전전두엽은 철수체계로서 혐오적인 자극에서 철수하려는 경향성과 부정적 정서를 발생시킨다는 보고가 있다[62]. 그러나 뇌파와 특정 인지능력 혹은 감정에 대한 관련성은 연구마다 일관적이지 않아[47] 특정 질병에 특정훈련을 일괄적으로 적용하는 것은 무리가 있어 훈련 전 뇌파 분석을 통해서 훈련자의 뇌파상태에 맞는 훈련모드를 사용하는 것이 임상현장에서는 보다 실제적일 것으로 사료된다.

평가지표로 공황장애, 주의력결핍 과다행동장애, 월경 전 평가 척도, 스트레스, 피로, 정서, 지능, 인지, 동기, 삶의 질, 통증 척도 등의 설문 평가와 신체계측, 혈중 신경인자, 혈액학적 분석, 면역세포, 심박변이도 등과 같이 신체변화를 측정하는 객관적 평가가 사용되었다.

그중 가장 많이 사용된 평가지표는 뇌기능 지수인데 뇌기능 지수는 특정 뇌파의 세기나 주파수, 혹은 뇌파간의 비율을 점수화 한 것이다[63]. 임상연구에서 뉴로피드백 훈련 후 뇌기능 지수가 유의미하게 변한 것은 뉴로피드백 훈련이 훈련자의 뇌파를 변화시켜 원하는 뇌파상태를 유도하였다는 것으로 해석할 수 있으나 뇌기능 지수가 신체적, 정서적 건강과 인지, 지능 등의 객관적 지표로 활용되기 위해서는 경험적 증거의 축척과 관련성 연구 등의 후속연구가 필요할 것으로 사료된다.

뉴로피드백 훈련의 훈련시간과 훈련횟수는 15분에서 60분, 4회에서 최대 90회로 다양하였고, 훈련 빈도와 훈련기간도 주 1회부터 1일 1회, 3일부터 9개월까지 다양하였다. 몇몇의 연구에서 원하는 뉴로피드백 훈련의 긍정적인 효과와 이를 지속적으로 유지하는데 필요한 훈련 횟수를 20회 이상으로 보고하고 있으나[64], 표준화된 치료 빈도 및 기간을 확립하기 위한 향후 연구가 필요할 것으로 생각된다.

뇌파는 인간의 정서 및 정신의 활동 상태와 관련을 가지므로 심신일여(心身一如)의 전인적 인체관에 기반한 한의학에서 진단적, 치료적 활용가능성이 높으며[11], 뇌파의 변화를 측정하여 원하는 방향으로 변화시키는 뉴로피드백 훈련 또한 인체 항상성을 유지하기 위한 자생력을 키워가는 자율적 훈련이란 점에서 한방정신요법과 일맥상통한 면이 있다[65]. 실제 한의학 임상현장에서 뉴로피드백 훈련이 사용되고 있고 그 효과와 한의학적 활용에 대해서 관심이 높아지고 있으나 한의학계에서의 임상연구는 증례보고에 치우쳐 있다.

이에 본 연구에서는 먼저 국내 학술지에 발표된 뉴로피드백 훈련 연구동향을 살펴서 실제 임상현장에서의 치료도구로의 활용과 한의학 연구의 설계에 참고하고자 했다.

선정된 연구를 살펴본 바 주의력결핍 과잉행동장애, 공황장애, 뇌졸중 후유증, 월경 전 불쾌장애, 측두하악장애, 비만 환자, 유아, 아동, 청소년, 성인 운동선수 등 다양한 집단을 대상으로 뉴로피드백 훈련에 대한 연구가 수행되고 있었으며, 증상개선, 스트레스 감소, 뇌기능 향상, 수행력 증가에 일정한 효과가 있었음을 알 수 있었다. 그러나 많은 수의 연구가 비질병인을 대상으로 하고 있고 특정 질환 및 증상을 대상으로 한 임상연구는 상대적으로 적어서 특정 질환에 대한 뉴로피드백 훈련의 치료효과에 대해 일반화하기 위해서는 더 많은 후속연구가 필요하다고 생각된다. 또한 연구의 질이 대체적으로 낮고 치료행위 외 다른 요소가 치료결과에 반영될 가능성이 배제되지 못하였기 때문에, 향후 연구에서는 뉴로피드백 훈련의 플라시보 효과의 가능성과 환자 및 치료자의 특성 등에 따른 다른 치료 요소가 미치는 영향을 고려한 정밀하고 과학적인 연구 설계와 분석방법이 요구된다.

뉴로피드백 훈련은 환자의 뇌파 상태에 맞는 훈련모드를 설정할 수 있고, 환자 주도하에 치료자와 상호 협조하여 치료한다는 점에서 한방정신요법과 유사한 점이 많아 한방신경정신과 질환의 치료에 응용될 수 있는 가능성을 크게 지닌다. 따라서 한의학 임상교육에 뉴로피드백 훈련의 임상적용을 확대함으로써 치료과정에 적극적으로 도입할 수 있을 것이며, 다양한 한의학적 치료와 함께 활용함으로써 뉴로피드백 훈련방식을 응용하는 등의 다양한 시도가 요구되며, 그 유효성에 대한 연구도 필요하다고 하겠다.

본 연구에서는 국내에 발표된 뉴로피드백 훈련에 대한 임상연구만을 대상으로 분석, 고찰하였으나 향후 해외 여러 나라에서 이루어지고 있는 연구에 대해서도 지속적 연구가 필요할 것이다.

V. 결론

본 연구는 뇌파를 이용한 생기능자기조절(뉴로피드백) 훈련의 한의학 임상에서의 활용제고를 위하여 2000년부터 2013년까지 국내학술지에 발표된 논문을 대상으로 분석, 연구동향을 고찰하여 다음과 같은 결론을 얻었다.

1. 뉴로피드백 훈련에 대한 임상연구는 총 37편으로 단일군 전후비교 연구가 6편, 뉴로피드백 훈련군과 대기군을 비교한 연구가 23편, 뉴로피드백 훈련과 다른 치료를 결합하거나 다른 치료군과 비교한 연구가 8편 보고되었다.

2. 뉴로피드백 훈련의 대상이 비질병인인 연구가 28편으로 가장 많았으며, 그 외 주의력결핍 과잉행동장애 혹은 학습능력저하 및 주의력 저하를 호소하는 아동을 대상으로 한 연구가 3편, 만성 뇌졸중 환자가 대상인 연구가 2편, 공황장애, 월경 전 불쾌장애, 측두하악장애, 비만 환자를 대상으로 한 연구가 각각 1편으로 보고되었다.

3. 뉴로피드백 훈련방법 절차, 시간, 회수, 빈도 및 평가방법은 연구대상과 질환에 따라 다양하게 나타났다.

4. 뉴로피드백 훈련 후, 단일군 전후 비교연구와 대기군을 대조군으로 한 연구에서 모두 뉴로피드백 훈련 후 유의성 있는 효과가 보고되었으나, 가짜 뉴로피드백 훈련을 대조군으로 한 연구는 2편 중 1편에서 뉴로피드백 훈련과 다른 치료를 비교한 연구는 8편 중 1편에서 뉴로피드백 훈련의 유의성 있는 효과가 보고되었다.

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