腦波分析實務：運動時之腦波

郭博昭 陽明大學腦科學研究所所長
李嘉宜 陽明大學腦科學研究所博士生
楊靜修 陽明大學睡眠研究中心主任

台灣9大學 登全球500大

免費索取300元優惠券

2010/09/08

【聯合晚報／國際新聞組／綜合報導】

中央社記者發自倫敦的報導說，根據英國高等教育調查機構QS公司最新公布的2010世界大學排行榜，今年前500名大學，台灣共有9所大學上榜，是歷年來最佳成績，其中台大排名第94名最佳。

負責這項調查的QS公司研究部主任梭特（Ben Sowter）接受中央社記者訪問時說，今年台灣的大學整體表現很好，從排名進步的情況來看，大學經營的方向也屬正確。

根據調查報告，台灣上榜的大學及排名分別爲：台大94名（較去年提高1名）、清華大學擠進前200大，由去年的223名

台灣上榜的大學排名

台灣大學	94名 （提高1名）
清華大學	196名（提高27名）
成功大學	283名（跌2名）
陽明大學	290名（提高16名）
交通大學	327名（提高62名）
台科大	370名（跌19名）
中央大學	398名
中山大學	401~450名之間
台師大	451~500名之間

K&Y Lab 簡介

郭博昭(Kuo, TBJ) 與楊靜修(Yang, CCH)的實驗室，於1999年共同成立於慈濟大學，並於2006年遷入陽明大學，持續進行各類生理訊號之研究，同時執行相關之教學與服務工作。

跑步沉澱 去煩解憂

中時電子報 www.chinatimes.com

更新日期:2010/08/26 03:28
張瑞益

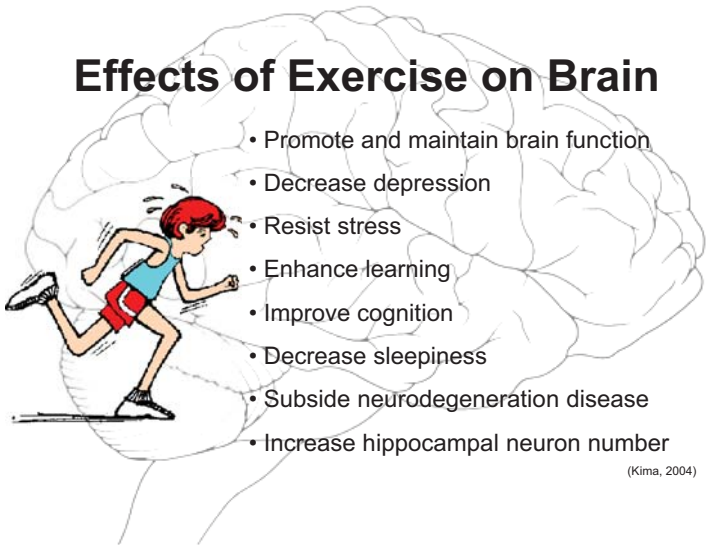
工商時報【張瑞益】

跑步有什麼樣的魔力，讓不少各界名人長年來都以此養生、健身。同樣對慢跑有特別愛好的是台灣證券交易所副總經理楊朝榮，從當年投入軍中被派到憲兵連（精誠連）當排長起，這一跑足足跑了30年，直到去年醫生要他多讓膝蓋休息，現在才「以走（騎）代跑」。楊朝榮說，不管是走路、跑步或現在經常傍晚騎自行車，每天的運動時間，都他一天難得的心靈沉澱時刻。

回想當年如何和跑步結下不解之緣，楊朝榮笑著說，當年他完成學業之後，當兵時莫名其妙地被分發到精誠連擔任排長，由於軍中要求嚴格，當時一般士兵要跑3千公尺，但楊朝榮的單位都是從6千公尺起跳，回想這一段記憶，楊朝榮笑得開心說：「沒辦法啊！當排長要帶兵，跑不動也要跑！」這一跑不僅讓楊朝榮此後的30年養成跑步運動、健身的習慣，連每天跑步的距離長年來也都維持6公里，從沒變過。

「跑步成癮」的楊朝榮，長年在辦公室都會有2雙運動鞋，一雙是晴天跑步用，另一雙則是專門用來對付多雨的北台灣；即使下雨，只要不是難以出門的大雨天，楊朝榮寧願在雨中享受跑步的

Effects of Exercise on Brain

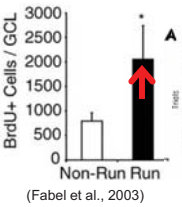


- Promote and maintain brain function
- Decrease depression
- Resist stress
- Enhance learning
- Improve cognition
- Decrease sleepiness
- Subside neurodegeneration disease
- Increase hippocampal neuron number

(Kima, 2004)

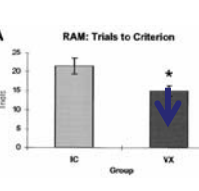
Effects of exercise

↑neurogenesis



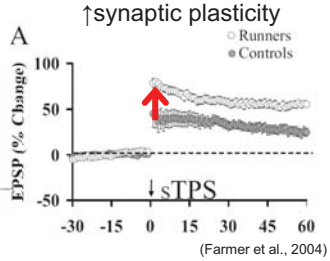
(Fabel et al., 2003)

↑learning



(Anderson et al., 2000)

↑synaptic plasticity



(Farmer et al., 2004)

NMDA-dependent synaptic plasticity

The difficulty to record electrophysiological signals during exercise

- Motion artifact
- Behavior interference
- Resist (in rodent)

Changes in electroencephalogram and heart rate during treadmill exercise in the rat

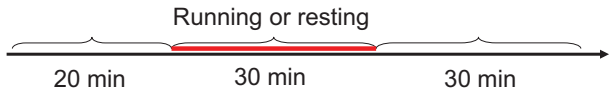
Jia-Yi Li, Terry B. J. Kuo, Sandy S. Y. Hsieh, Cheryl C. H. Yang

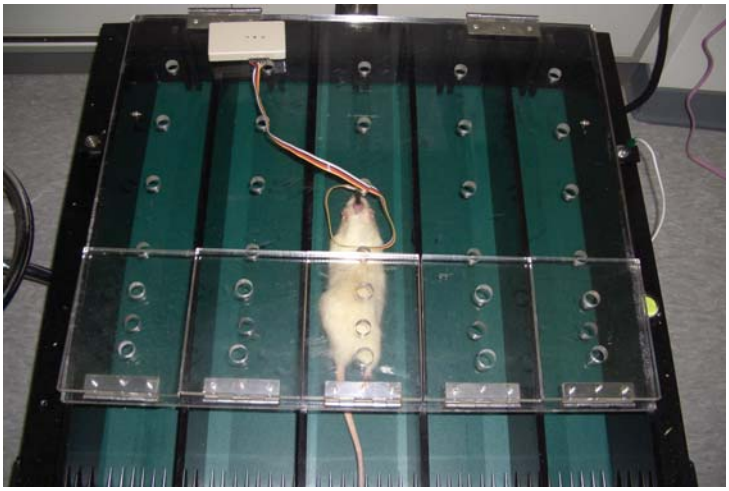
Specific aim

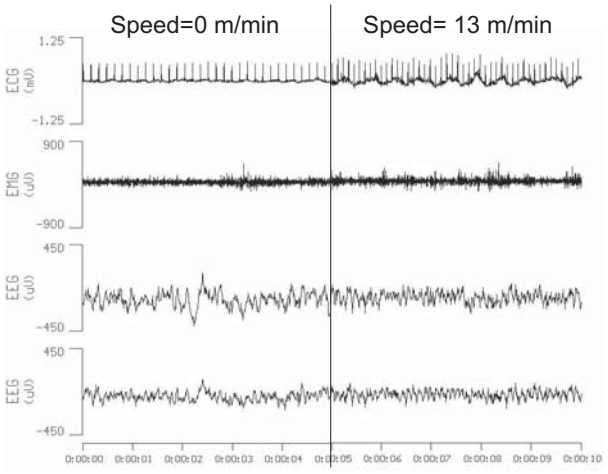
To determine whether and how the rat's brain responds to exercise.

Methods

- Animal preparation
  - 6-7 wks old male WKY (n=10)
  - implantation of electrode
- Recorded for 80 min (AM 6:00 to 7:30)
  - during dark period







neocortex EEG

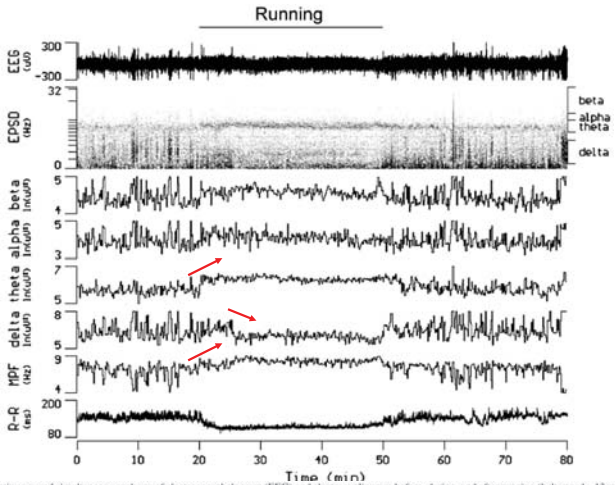
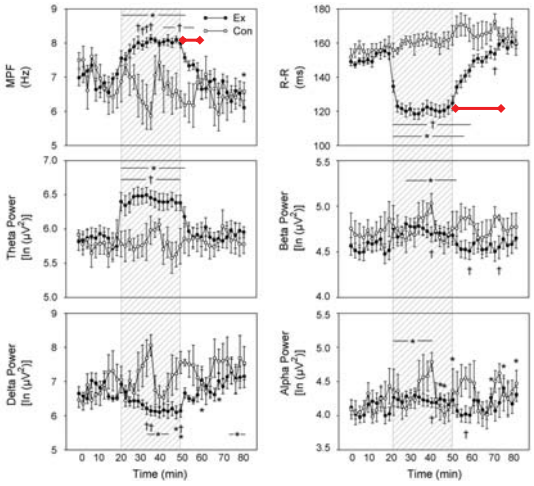


Fig. 1. Continuous and simultaneous analyses of electroencephalogram (EEG) and electrocardiogram before, during, and after running (belt speed = 13 m/min) on a treadmill in a rat. The power spectrograms of EEG (EPSD) showed successive changes in the power spectral density within 0 and 32 Hz. Temporal alterations in the beta, alpha, theta, and delta powers, the mean power frequency (MPF) of the EEG, and the mean of the R–R interval (R–R) are shown. Ranges of frequency for the beta, alpha, theta, and delta powers of the EEG are denoted on right side of the spectrograms. ln = natural logarithm.



*p < 0.05 vs. the last point before exercise in the exercise group
†p < 0.05 vs. the control group

Summary

- To provide an efficient way to observe the interaction of brain and heart activities during strenuous exercise.
- Alpha & beta - vigilance, alertness and attention
- Theta during running - related to memory and cognitive functions
- The order of the changes during exercise
  ➔ provide the useful hints as to the cause/effect relationship between cerebral activity and autonomic functioning

Neuroscience Letters, 2008

Effect of aging on treadmill exercise induced theta power in the rat

Terry B. J. Kuo, Jia-Yi Li, Sandy Shen-Yu Hsieh, Jin-Jong Chen, Ching-Yao Tsai, Cheryl C. H. Yang

Theta wave of EEG

- Sleep propensity (Torsvall & Akerstedt, 1987; Vyazovskiy & Tobler, 2005)
- Cognition and memory (Gevin et al., 1997; Klimesch 1999)
- Attention and motivation (Bennett et al., 1973)
- Integration of motor programming (Morris and Hagan, 1983)
- Hippocampal theta in rats
  locomotion, orienting, spatial learning, memory, REM sleep (Winson, 1978; Bland, 1985)

  Type 1: large movement

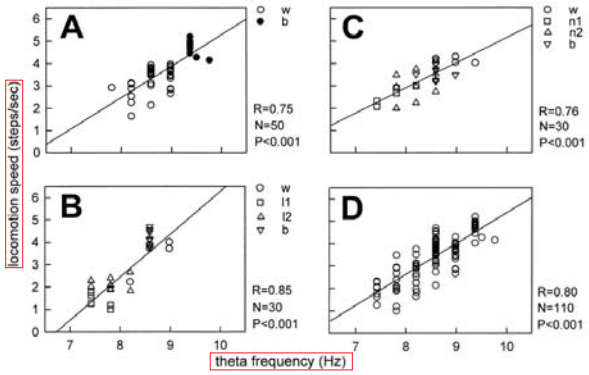
  Type 2: REM sleep & anesthesia

Characteristic of theta rhythms

- Theta amplitude
  - sleep propensity
  - locomotion magnitude
  - environment
  - spatial learning
- Theta frequency
  - speed of locomotion
  - motivation

Brain Res Bull 62 (2004)379-384; Exp Brain Res 145 (2002)383-394; Neuroscience 60 (1994) 441-445
Neuroscience & Biobehavioal Reviews 22 (1998) 221-231; Brain Research 796 (1998) 327–331

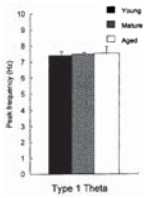
Speed & locomotion induced theta, free running



Slawinska and Kasicki, 1998

Effect of aging on locomotion induced theta

- ⇔ amplitude in rat's hippocampus (Barnes, 1979)
- ⇔ amplitude, ⇩ frequency in rat's hippocampus (Markowska, et al., 1995)
- ⇔ amplitude, ⇩ frequency (subtle) in rat's hippocampus (Shen et al, 1997)
- ⇔ amplitude, ⇔ frequency in rat's hippocampus (Abe and Toyosawa, 1999)
- ⇩ amplitude in human's fronto-central midline scalp (Cummins and Finnigan, 2007)
- "The theta rhythm does not differ between adult and old rats." (Orr et al., 2001)



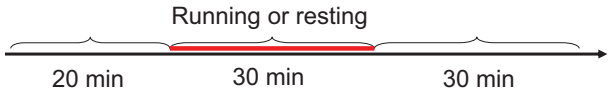
Abe and Toyosawa, 1999

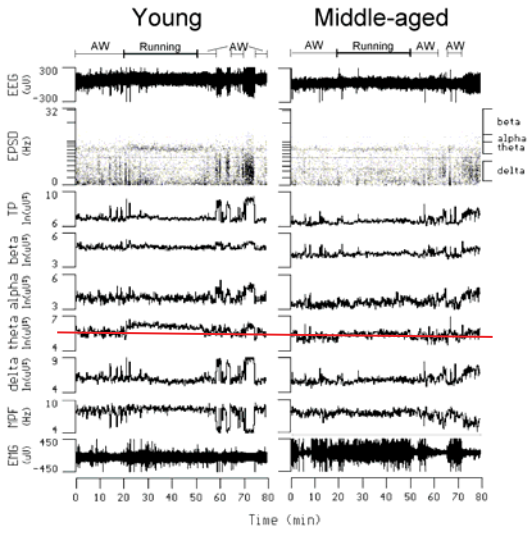
Specific aims

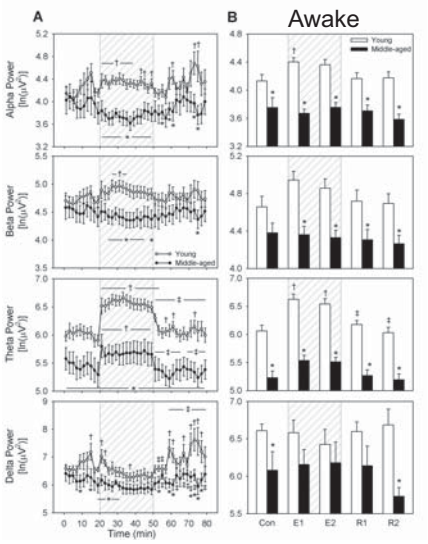
- To confirm whether **brains of awake young rats** showed a significantly response to treadmill exercise when compared to before exercise.
- To determine whether **older rats have a lower baseline level and/or show a lower response** to exercise than young rats
- To determine whether treadmill exercise is still able to evoke brain activity in the older rats.

Methods

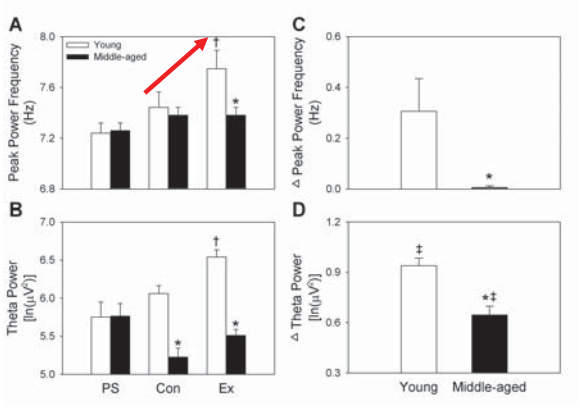
- Animal preparation
  - 8 and 60 wks old male WKY (n=8)
  - implantation of electrode
- Recorded for 80 min (AM 6:00 to 7:30)
  - during dark period







*p< 0.05 vs. the same time point of the young rats.
†p< 0.05 vs. the last point before exercise or the Con of the same group.
‡p< 0.05 vs. the last point during exercise or the E2 of the same group.



- Baseline↓
- Exercise evoked response ↓
- Adult during exercise theta ↑

*:adult with young WKY
†: compared with B

Summary

- Aging in rats may lower theta power EEG spectra during waking and produce a lower response to running stimuli.
- We offered electrophysiological evidence for aging-related changes in exercise-evoked theta power.

Age, 2010

Author's personal copy

Effect of aging on treadmill exercise induced theta power in the rat

Terry B. J. Kuo · Jia-Yi Li · Sandy Shen-Yu Hsieh · Jin-Jong Chen · Ching-Yao Tsai · Cheryl C. H. Yang

Received: 19 November 2009 / Accepted: 29 March 2010 / Published online: 22 April 2010
© American Aging Association 2010

Abstract The effects of aging on the electroencephalogram (EEG) power spectra of 8- and 60-week-old Wistar–Kyoto rats were examined during the waking baseline and treadmill exercise. Using continuous and simultaneous recordings of EEG and electromyogram signals, this study demonstrated that the alpha (10–13 Hz), theta (6–10 Hz), and delta (0.5–4 Hz) powers of the EEG were significantly lower in older rats as compared with young rats during the waking baseline. In the young rats, treadmill exercise resulted promptly in a higher alpha power, higher theta power, and higher theta power percentage as compared with the waking baseline. In the aged rats, treadmill exercise only resulted in a higher theta power and higher theta power percentage. During the treadmill exercise, however, the aged rats still showed a significantly lower exercise-evoked theta power change than the young rats. These results suggested that aging is accompanied by lower EEG activities during waking and this also is accompanied by an attenuated response of the brain to exercise in the rat.

Keywords EEG spectra · Waking status · Treadmill exercise · Aging · During exercise · Theta power of the EEG

T. B. J. Kuo and J.-Y. Li contributed equally to this study.

T. B. J. Kuo · J.-Y. Li · C. C. H. Yang (✉)
Institute of Brain Science, National Yang-Ming University, No. 155, Sec. 2, Li-Nong St., Beitou, Taipei 11221, Taiwan
e-mail: cchyang@ym.edu.tw

T. B. J. Kuo
e-mail: dkjkuo@ym.edu.tw

J.-Y. Li
e-mail: jyli@ym.edu.tw

T. B. J. Kuo · J.-Y. Li · J.-J. Chen · C. C. H. Yang
Sleep Research Center, National Yang-Ming University, No. 155, Sec. 2, Li-Nong St., Beitou, Taipei 11221, Taiwan

J.-J. Chen
e-mail: jjchen@ym.edu.tw

T. B. J. Kuo · J.-J. Chen · C.-Y. Tsai · C. C. H. Yang
Department of Education and Research, Taipei City Hospital, Taipei 10341, Taiwan

C.-Y. Tsai
e-mail: hsilimo@yahoo.com.tw

S. Shen-Yu Hsieh
Graduate Institute of Exercise and Sport Science, National Taiwan Normal University, Taipei 10610, Taiwan
e-mail: 698020@ntnu.edu.tw

J.-J. Chen
Department of Physical Therapy and Assistive Technology, National Yang-Ming University, Taipei 11221, Taiwan

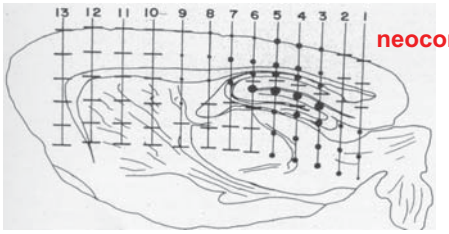
Springer

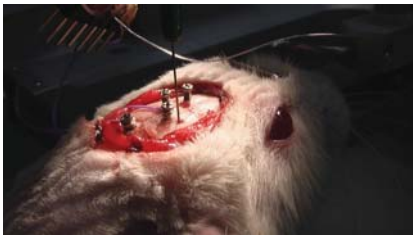
Change of hippocampal theta activity during initiation and maintenance of running in the rat

Terry B. J. Kuo, Jia-Yi Li, Cheryl C. H. Yang
in preparation

- Exercise alters state of consciousness has been found in athletes. (Dietrich, 2003)
- Theta rhythm ⇔ cortical arousal in rodents (Vinogradova, 1995; Kahana et al, 2001)
- Hippocampal theta rhythm ⇔ locomotion and sensory information (Vanderwolf, 1969; Kemp and Kaada, 1975; Oddie and Bland, 1998; Bland and Oddie, 2001; Shin and Talnov, 2001; Nerad and Bilkey, 2005; Bland et al, 2006)
- **Free running** evokes the theta amplitude of the EEG. (Teitelbaum et al, 1975; Buzsaki et al, 1981; Angyan et al, 1998;Slawinska et al, 1998; Nielsen et al, 2001; Crabbe et al, 2004; Gengler et al, 2005)
- Free running = running + resting ≠ running

rare electrophysiological evidence





Running exercise is not homogeneous

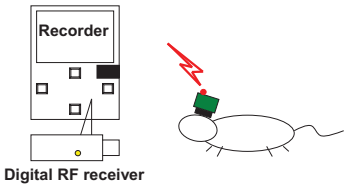
- Metabolism
  - aerobics vs. anaerobic
- Fatigue
  - high EMG activity vs. low EMG activity
- Personal perception
  - smooth vs. uneven

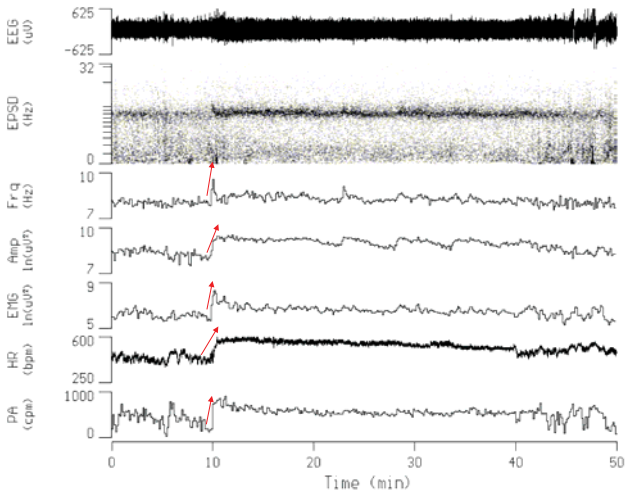
Specific aims

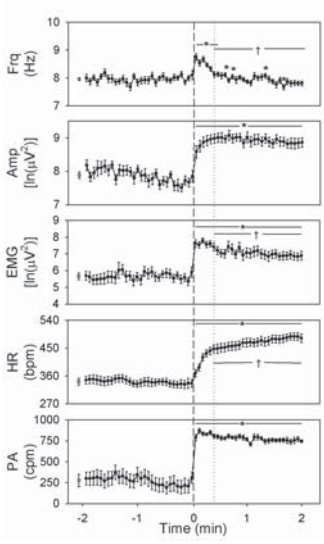
- To determine whether a running exercise can be classified into different stages according to EEG responses.
- To understand the electrophysiological characteristics of the **initiation of exercise**.
- To determine the contribution factor for hippocampal theta activity during **maintenance of exercise**.

Methods

- Animal preparation
  - 8 wks old male WKY (n=15)
  - implantation of the electric sensors
- **Wireless recording system**
  - EEG, EMG and ECG

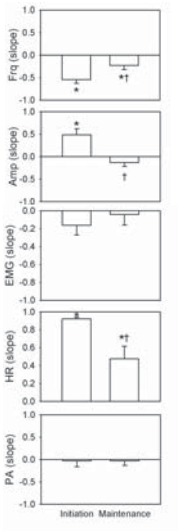






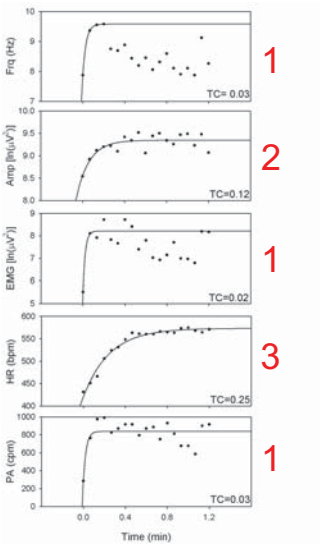
*p < 0.05 vs. mean value of before running (open circle)
†p < 0.05 vs. the first point during exercise

Frq, Amp and HR
➔ different slopes in two stages

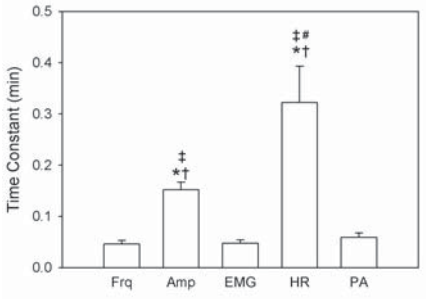


*p < 0.05 from zero by 95% confidence interval analysis
†p < 0.05 vs. the initiation of exercise

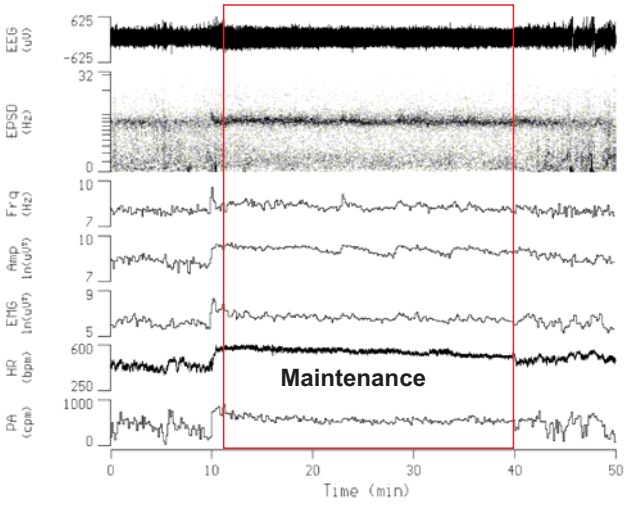
A typical example of time constants (TC) in hippocampal theta frequency (Frq) and power (Amp) of electroencephalogram, electromyogram power (EMG), heart rate (HR), and physical activity (PA) as initiation of exercise in one rat are shown.



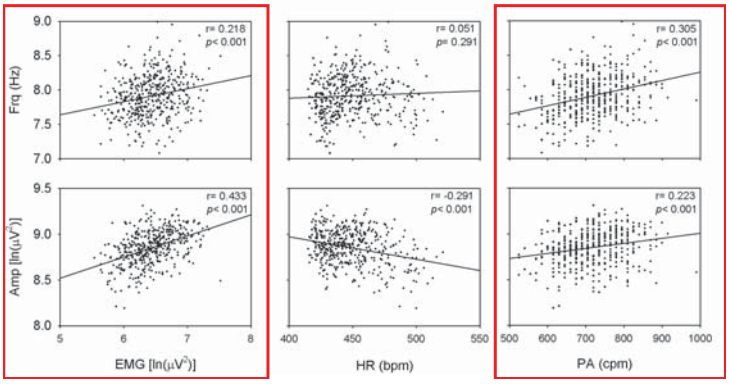
Quantitative analyses of time constants in hippocampal theta frequency (Frq) and power (Amp) of electroencephalogram, electromyogram power (EMG), heart rate (HR), and physical activity (PA) in rats



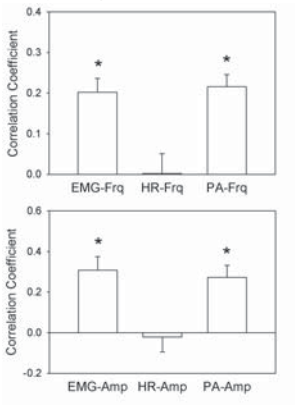
*p < 0.05 vs. EMG, †p < 0.05 vs. PA, ‡p < 0.05 vs. Frq, #p < 0.05 vs. Amp.



Two-dimensional scattergram showing the relationship between hippocampal theta components (frequency, Frq; amplitude, Amp) and corresponding parameters of body movement (electromyogram power, EMG; heart rate, HR; physical activity, PA)



The correlation coefficients between hippocampal theta components (frequency, Frq; amplitude, Amp) and parameters of body movement (electromyogram power, EMG; heart rate, HR; physical activity, PA) in rats



*p < 0.05 from zero by 95% confidence interval analysis.

Summary

- The running exercise is heterogenous and can be classified into initiation and maintenance according to EEG responses.
- A switch for theta amplitude during initial movement: theta frequency.
- Maintenance: positive correlation between theta component and physical activity.
- Our finding may provide electrophysiological evidences for psychologists with exercise treatments on patients.