科技部補助專題研究計畫成果報告
期末報告

綠茶對連續高強度運動誘發之高氧化壓力與免疫反應之調控與其分子機制探討(第3年)

計 畫 類 別 ： 個別型計畫
計 畫 編 號 ： NSC 101-2628-H-028-002-MY3
執 行 期 間 ： 103年08月01日至104年07月31日
執 行 單 位 ： 國立臺灣體育運動大學競技運動系

計 畫 主 持 人： 方世華
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報 告 附 件 ： 出席國際會議研究心得報告及發表論文

處 理 方 式 ：
1.公開資訊：本計畫涉及專利或其他智慧財產權，2年後可公開查詢
2.「本研究」是否已有嚴重損及公共利益之發現：否
3.「本報告」是否建議提供政府單位施政參考：否

中 華 民 國 104 年 10 月 06 日

中 文 摘 要 ： 本研究的主要目的在探討跆拳道選手血液中的吞噬細胞在不同濃度的各種綠茶多酚作用下產生發炎細胞激素之反應。10位跆拳道選手在訓練後收集血液。進一步分析血液後發現不同濃度的各種綠茶多酚對於一氧化氮、發炎細胞激素如介白素-6的產生並無明顯的影響，但(-)-catechin and EGCg會抑制腫瘤壞死因子的產生，其他的多酚類則無明顯的影響。在各種綠茶多酚抑制吞噬細胞作用的機轉可能是透過對於Akt磷酸化的抑制作用。此初步的研究結果可以提供有關綠茶達到運動後免疫功能之相關調節機轉。

中 文 關 鍵 詞 ： 運動免疫反應；綠茶多酚；吞噬細胞；發炎細胞激素

英 文 摘 要 ：

英 文 關 鍵 詞 ：

前言

Taekwondo (TKD) is a high speed, high tension, full-contact combat sport and the training program for TKD athletes includes a series of intensified, vigorous physical exercises. However, acute effects of TKD training on individual mucosa immunity with or without green tea consumption are still poorly understood. Therefore, development of nutritional strategies to alleviate the negative effects of high-intensive exercise would seem particularly desirable. Green tea is a non-fermented/oxidized tea and contains various polyphenolic flavonoids, including (-)-epigallocatechin-3-gallate (EGCG), (-)-epicatechin gallate (ECG), (-)-epigallocatechin (EGC), (+)-gallocatechin gallate (GCG), (-)-epicatechin, (+) gallocatechin (GC) and (+)-catechin. The (-)-catechin is the negative form of catechin. We investigated the anti-inflammatory effects of polyphenols of green, including gallic acid, (+)-catechin, (-)-catechin, epicatechin and EGCG in stimulated immune cells.

研究目的

Thus, in this study, we investigated the anti-inflammatory effects of polyphenols of green, including gallic acid, (+)-catechin, (-)-catechin, epicatechin and EGCG in stimulated immune cells.

文獻探討

Our previous results indicate that the cumulative effects of prolonged, strenuous TKD training in combination with rapid weight loss can significantly suppress the mucosal immunity of male and female TKD athletes (Tsai et al. 2011a; 2011b). Many factors presented in mucosal secretions serve as a first line of defense against microbial infection, including immunoglobulins, α-amylase and anti-microbial peptides (Amerongen and Veerman 2002; West et al. 2006). Prolonged, strenuous exercise has been implicated in immunosuppression, induction of inflammatory response and increased production of free radicals (He et al. 2010; Laing et al. 2005).

Furthermore, gallic acid is a component of polyphenols from green tea. Catechin consists of a flavan-3-ol structure that contains two or more aromatic rings (Graham 1992). Consumption of green tea has been reported having many beneficial health effects, such as anti-oxidative activity, and immunomodulatory effects (Katiyar 2003; Tipoe et al. 2007). On the major green tea polyphenol, EGC, ECG, and EGCG are polyphenol with pyrogallol-type structures. In contrast, (+)-catechin, (-)-catechin and (-)-epicatechin are polyphenols without pyrogallol-type structures. Moreover, gallic acid is a galloyl moiety.

Several pro-inflammatory cytokines such as TNF-α, IL-1β and IL-6 are secreted from the tissue-infiltrating macrophages, and cause chronic low-grade inflammation.

Mitogen-activated protein kinase (MAPK) pathways mediate intracellular signal and regulate pro-inflammatory and anti-inflammatory cytokine production in response to stimulation of LPS (Guha M et al., 2001), and the secretion of several pro-inflammatory cytokines and inflammatory mediators. MAPK pathways include ERK1/2, p38, and JNK. Especially, p38 MAPK pathway is a critical role in downstream of TLR4-mediated activation (Bode JG et al., 2012). Activation of TLR4 in macrophages is associated with the innate immune response to infection. Among the polyphenols of green tea, ECGC is the most abundant polyphenol, and has been studied well. EGCG exerts anti-inflammatory effects in LPS-stimulated macrophages, such as a decrease in the production of the pro-inflammatory cytokines TNF-α and IL-6 and inflammatory mediator NO, and suppression of MAPKs (ERK1/2, p38, and JNK) and nuclear factor-κB (NF-κB) signaling pathways (Hong Byun E et al., 2010 ; Joo SY et al., 2012; Singh U et al., et al., 2005). However, the other polyphenols of green tea have not been fully investigated, especially, the anti-inflammatory effects of gallic acid and polyphenol without pyrogallol-type structure ((+)-catechin, (-)-catechin, (-)-epicatechin). Thus, in this study, we investigated the anti-inflammatory effects of polyphenols of green, including gallic acid, (+)-catechin, (-)-catechin, epicatechin and EGCG in LPS-stimulated macrophages.

The amount and the source of energy intake, fluid replacement, as well as the ingestion of stimulants such as caffeine are important factors directly linked to sport performance in endurance events.

研究方法

Participants and Study design

Ten male cyclists from the National Taiwan University of Sport volunteered to participate in this study. This study protocol was approved by the Human Ethics Committee of the National Taiwan University of Physical Education and Sport before the start of this study. Written informed consent was obtained from each participant after detailed explanation of the study.

Reagents

The pure compounds gallic acid (monohydrate) and (-)-catechin were obtained from Wako Chemicals (Osaka, Japan). The pure compounds (+)-catechin (hydrate), (-)-epicatechin and EGCG were obtained from Sigma-Aldrich (St. Louis, USA) (Fig. 1). The p38 MAPK, p-p38 MAPK and β-actin antibody were purchased from Cell Signaling Technology, Inc. (Beverly, USA).

Polyphenol treatment and LPS challenge

Cells were seeded on per well of 6-well plate at a concentration of 1.45×10^6 cells, and were allowed to acclimate for 24 h. After 24 h, cells were pre-treated with various concentrations (1 μM and 10 μM) of polyphenols (gallic acid, (+)-catechin,

(-)-catechin, (-)-epicatechin and EGCG) for 4 h. After pre-treatment with polyphenols, cells were washed with D-PBS before treatment with LPS. The cells were stimulated with LPS (50 ng/ml) (Sigma-Aldrich, St. Louis, USA) for 24 h. The supernatant and whole cell lysate were harvested and stored frozen at -80°C until analysis.

Total protein analysis

The total protein of the cells was used to detect the effects of green tea polyphenols on cell growth/viability (Huang H et al., 2012). Cells were lysed in 100 μl RIPA buffer (Thermo Scientific, Rockford, USA). The whole cell lysate was used for determination of protein concentration using the micro-bicinchoninic acid (BCA) assay (Thermo Scientific, Rockford, USA), according to the manufacturer's instruction.

Cytokine measurement

The production of TNF-α, IL-1β, and IL-6 were measured by enzyme-linked immunosorbent assay (ELISA). The cell supernatant (100 μl) was used for determination of cytokine concentration by ELISA (R&D Systems, Minneapolis, USA) according to the manufacturer's protocol. TNF-α concentration was measured using a TNF-α DuoSet ELISA kit (range: 31.2 - 2,000 pg/ml) (R&D Systems, Minneapolis, USA). IL-1β concentration was measured using a IL-1β DuoSet ELISA kit (range: 15.6 - 1,000 pg/ml) (R&D Systems, Minneapolis, USA). IL-6 concentration was measured using a IL-6 DuoSet ELISA kit (range: 15.6 - 1,000 pg/ml) (R&D Systems, Minneapolis, USA).

Western blotting

Cells were lysed in 100 μl RIPA buffer (Thermo Scientific, Rockford, USA), and the cell lysates were centrifuged at 16,000g for 20 min at 4°C, and the supernatant was collected as whole-cell extracts. For Western blotting, equal amount of cellular proteins (whole-cell extracts: 10 μg/lane) were separated by electrophoresed on a 10% SDS-polyacrylamide gel, and transferred to PVDF membranes. The membranes were blocked with 5% BSA in TBST (0.05% Tween 20) for 1 h at room temperature, and incubated overnight with primary antibodies (1:1,000). After hybridization with primary antibodies, the membranes were washed three times with TBST for 5 min, and then incubated with horseradish peroxidase (HRP)-conjugated secondary antibody for 40 min at room temperature. After hybridization with HRP-conjugated secondary antibody, the membranes were washed six times with TBST for 5 min. Epitopes on proteins recognized specifically by antibodies were visualized by using ECL Prime Western Blotting Detection Reagent (GE Healthcare, Little Chalfont, U.K.). Band intensities were quantified using ImageJ software (NIH, Bethesda, USA).

Statistical analysis

All results are expressed as means ± standard error of the mean (SEM). Each value is the mean of three independent experiments. Statistical analysis was

performed using SPSS V22.0 (IBM, Tokyo, Japan). The *p* values were determined by two-way ANOVA, and repeated measures with Bonferroni post-hoc tests. The p values of <0.05 were considered statistically significant.

結果

Gallic acid and EGCG exhibit protection of cell growth/viability on LPS-stimulated macrophages

Macrophages were pre-treated with or without various concentrations of polyphenols of green tea for 4 h, and stimulated with 50 ng/ml LPS for 24 h. The total protein of cells decreased when stimulated with LPS for 24 h. As shown in Fig. 2A, the pre-treatment of 10 μM gallic acid and EGCG significantly prevented this decrease in total protein of LPS-stimulated macrophages ($p<0.05$). The pre-treatment with 10 μM (-)-catechin also produced the similar effect, but it was not significant ($p=0.07$). Pre-treatment of 10 μM EGCG was significantly more effective than pre-treatment with 10 μM (+)-catechin for preserving cell viability ($p<0.05$). Meanwhile, the nitric oxide (NO) productions were monitored as shown in Fig. 2B.

Gallic acid, (-)-catechin and EGCG inhibit the release of LPS-induced TNF-α and IL-6 in macrophages

Both pre-treatment with 1 μM and 10μM EGCG suppressed the production of TNF-α by LPS-stimulated macrophages significantly as shown in Fig. 3A ($p<0.05$). Pre-treatment with 1 μM and 10μM (-)-catechin also significantly suppressed the production of TNF-α ($p<0.05$). Furthermore, pre-treatment with 10 μM gallic acid significantly suppressed the production of TNF-α ($p<0.05$). At the concentration of 10 μM, production of TNF-α was greater in response to treatment with (+)-catechin and (-)-epicatechin compared with EGCG ($p<0.05$). Pre-treatment with 1 μM and 10 μM EGCG and (-)-catechin suppressed the production of IL-6 by LPS-stimulated macrophages ($p<0.05$). Pre-treatment with 10 μM gallic acid also suppressed IL-6 production ($p<0.05$) (Fig. 3B). The concentration of IL-1β following stimulation with LPS was too low to detect (data not shown).

The polyphenols with a flavan-3-ol structure regulated production and phosphorylation of p-38 MAPK

Macrophages were pre-treated with or without 10 μM of polyphenols of green tea for 4 h, and stimulated with 50 ng/ml LPS for 45 min and 2 h. LPS-induced production and phosphorylation of p38 MAPK was increased at 45 min (early stage), but after LPS challenge 2 h (late stage) was decreased compared with LPS challenge for 45 min. As shown in Fig. 4, pretreatment with polyphenols that have a flavan-3-ol structure (i.e., (+)-catechin, (-)-catechin, (-)-epicatechin and EGCG) enhanced total expression and phosphorylation of p38 MAPK after LPS challenge 45 min. By contrast, total expression and phosphorylation of p38 MAPK were suppressed after

LPS challenge for 2 h. Interestingly, after LPS challenge for both 45 min and 2 h, gallic acid neither enhanced nor suppressed production and phosphorylation of p38 MAPK.

討論

The inflammatory response of macrophages plays a crucial role in the acute innate immune response of host defense against infection, and is associated with development of chronic inflammatory diseases (Bjorkbacka H et al., 2004; Drexler SK et al., 2010). The dysregulation of macrophage activity is involved in pathogenesis of chronic inflammatory diseases through overproduction of pro-inflammatory cytokines (Mohammad MK et al., 2006). TLR4-induced inflammatory signaling pathway is an integral part of inflammatory response of macrophage. In this study, we induced inflammatory responses in macrophages using the TLR4-ligand LPS, and investigated the anti-inflammatory effects of polyphenols of green tea.

In a previous study, Hong Byun et al. demonstrated that EGCG inhibited production of TNF-α and IL-6 by LPS-stimulated mouse peritoneal macrophages (Hong Byun E et al., 2010). Our results show that polyphenols of green tea with pyrogallol-type structure, such as EGCG and gallic acid have anti-inflammatory effect on LPS-stimulated RAW cells. Concerning the anti-inflammatory effect of gallic acid, only pre-treatment with 10 μM gallic acid affected production of TNF-α and IL-6 of LPS-stimulated RAW cells. Furthermore, among the polyphenols in green tea without pyrogallol-type structure, only (-)-catechin suppressed production of TNF-α and IL-6 of LPS-stimulated RAW cells. These results suggest that a pyrogallol-type structure is an important factor in the anti-inflammatory effects of the green tea polyphenols. In previous studies of catechin, Singh et al. demonstrated that catechin attenuated the production of TNF-α by LPS-stimulated human monocytic cell line THP-1 cells (Singh U et al., 2005), but Youn et al. found that catechin did not suppress NF-κB activation of LPS-stimulated RAW cells (Youn HS et al., 2006). NF-κB activation is major upstream signaling for secretion of TNF-α. Thus, the form of catechin used might be different in these previous studies. Our results demonstrated that (-)-catechin exerted anti-inflammatory effects in LPS-stimulated RAW cells, but (+)-catechin did not suppress pro-inflammatory cytokine production on LPS-stimulated RAW cells.

MAPK pathways are important pathways which response toward LPS stimuli and mediate TLR4-induced signaling factors. MAPK pathways enhance activation of NF-κB, the core of production of pro-inflammatory cytokines (Guha M et al., 2001). In the LPS-induced MAPK pathway, the total expression and phosphorylation of MAPK increased in the early stage, whereas it was diminished in the late stage (Chen CC et al., 1999; Karahashi H et al., 2003). Our results demonstrated that polyphenols

with a flavan-3-ol structure enhanced production and phosphorylation of p38 MAPK in early stage (after 45 min LPS challenge). This result suggests that polyphenols with a flavan-3-ol structure accelerate the response toward LPS on p38 MAPK pathway. In the present study, the in late stage (after 2 h LPS challenge). On the other hand, gallic acid neither enhanced nor attenuated the expression and phosphorylation of p38 MAPK, which suggests that the anti-inflammatory effect of gallic acid on LPS-stimulated macrophages is regulated through other pathways.

計畫成果自評部份：

目前研究內容與原計畫相符程度約 70%，這一部分的研究成果將先整理寫成論文投稿至國際學術期刊。

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Figure 1 Chemical structure of polyphenol of green tea

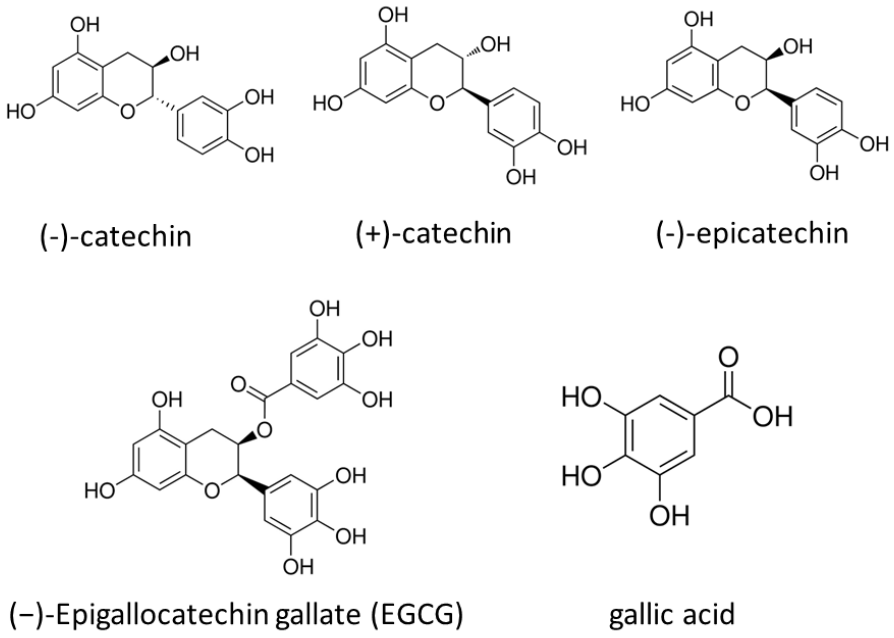


Figure 2A

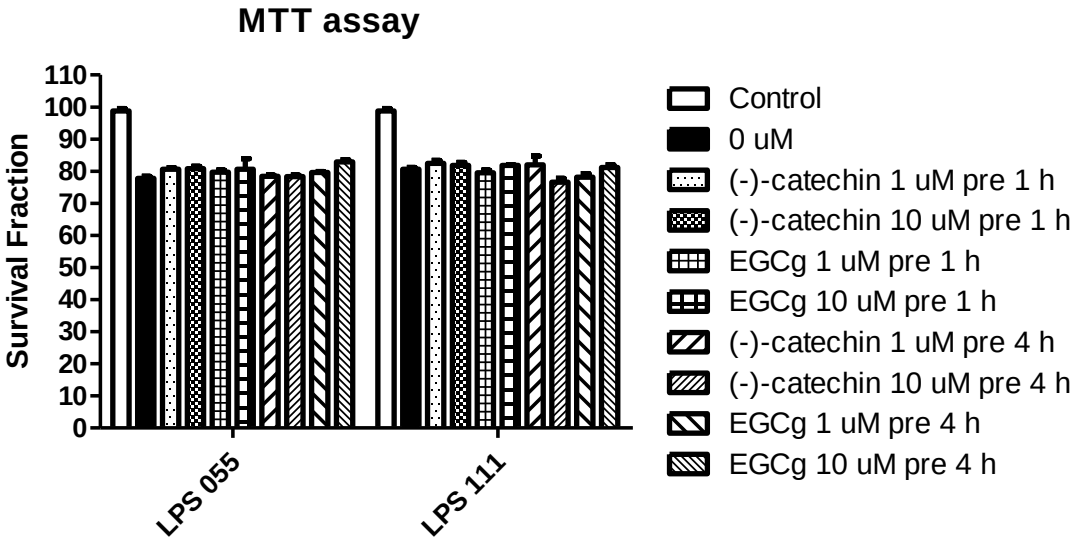


Figure 2B

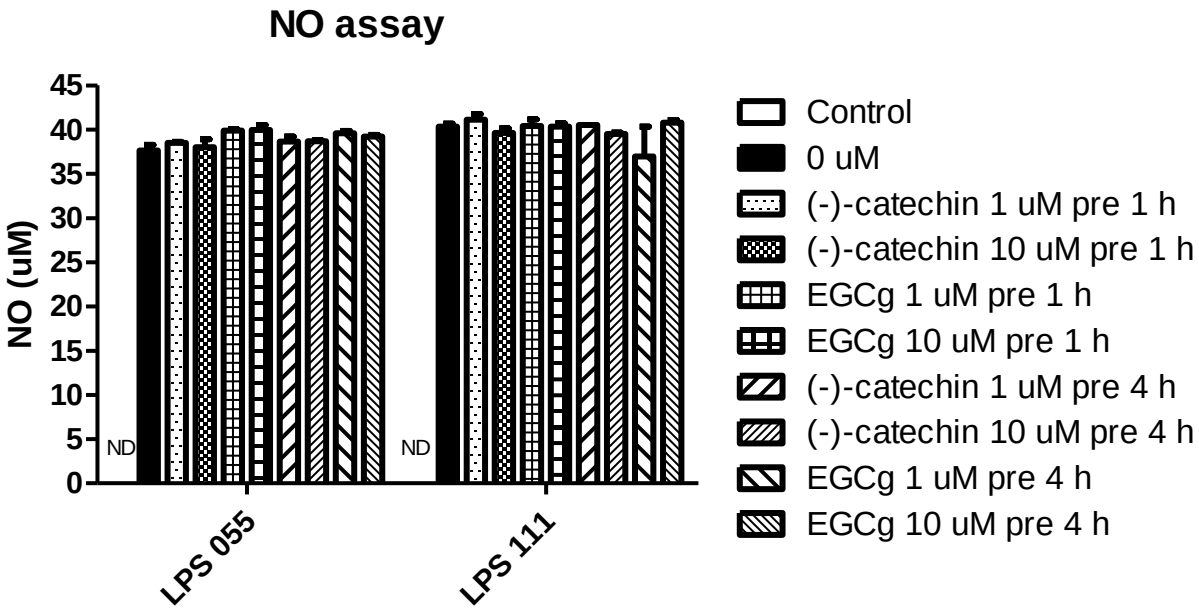


Figure 3A

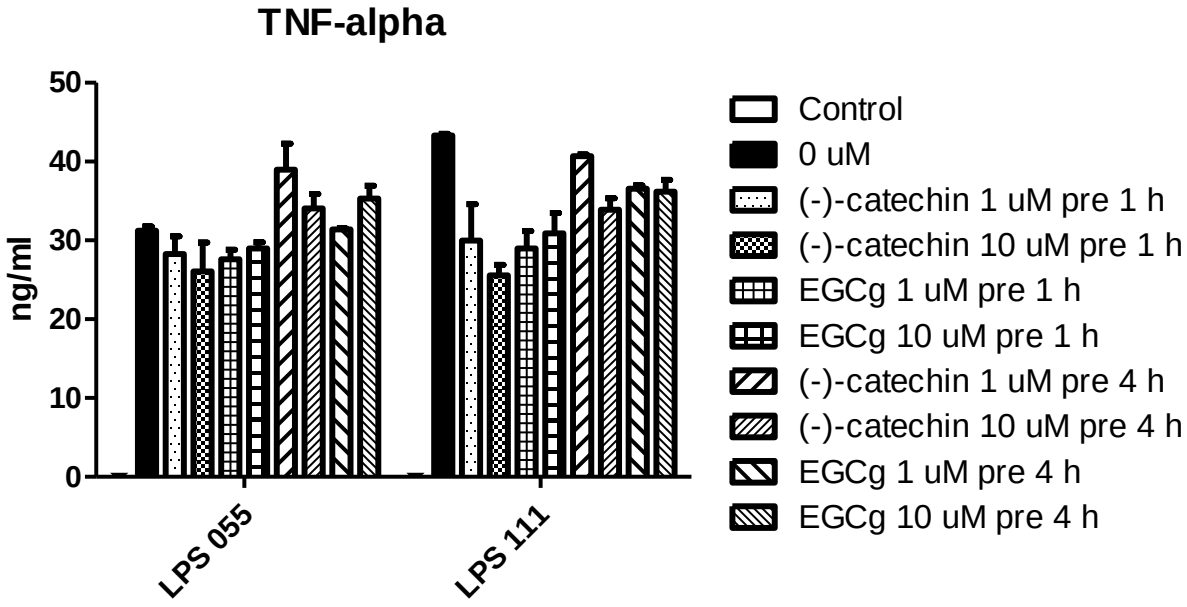


Figure 3B

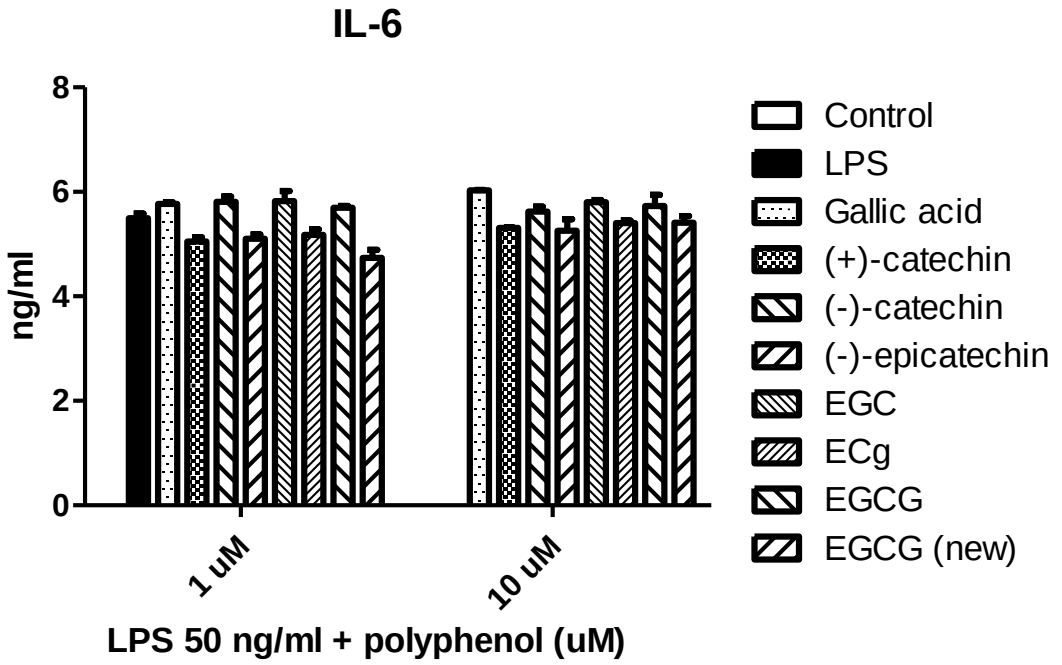
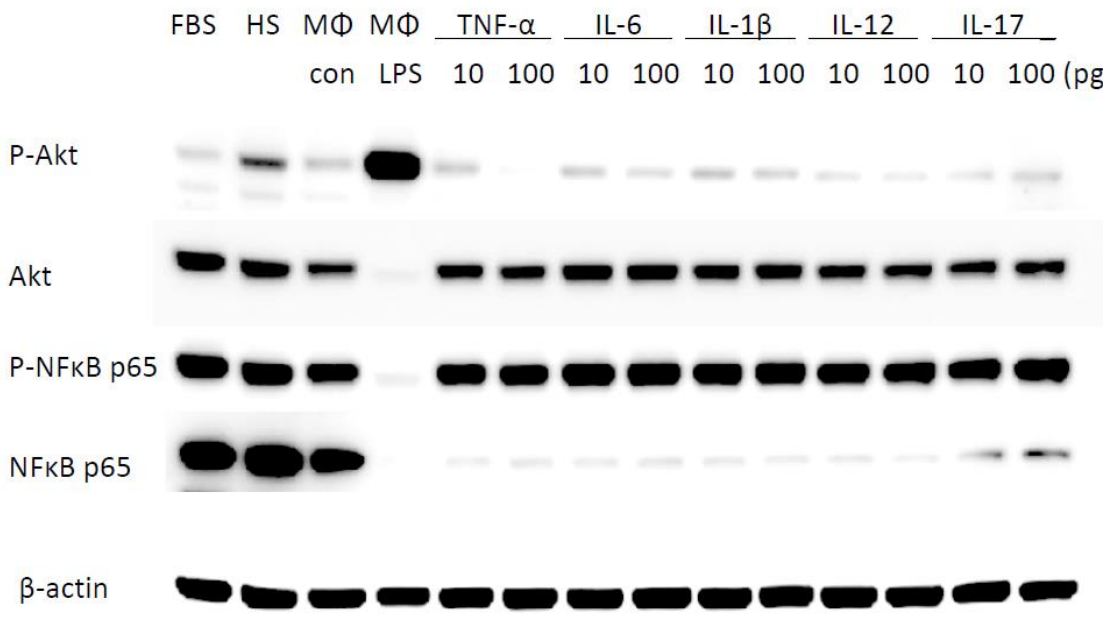


Figure 4



國科會補助專題研究計畫出席國際學術會議心得報告

日期：104 年 3 月 20 日

計畫編號	NSC 101－2628－H－028－002－MY3		
計畫名稱	綠茶對連續高強度運動誘發之高氧化壓力與免疫反應之調控與其分子機制探討		
出國人員 姓名	方世華	服務機構 及職稱	臺灣體育運動大學 競技運動學系　教授
會議時間	104 年 3 月 4 日 以及 104 年 3 月 6 日	會議地點	日本東京 Tokyo, Japan
會議名稱	(中文)第 1 屆健康促進:體育運動的樂趣國際研討會以及第 3 屆壓力與疾病國際研討會 (英文) *1st international symposium: Health promotion—The Joy of Sports and Exercise* AND 3rd symposium on stress responses and diseases		
發表題目	(中文)綠茶多酚的結構特性對脂多醣體活化吞噬細胞株之作用 (英文) The structural characteristics of green tea polyphenol on LPS-stimulated RAW cells		

一、參加會議經過

第 1 屆健康促進:體育運動的樂趣國際研討會是由日本早稻田大學運動科學研究所主辦的健康促進全球計畫，這是早稻田大學運動科學研究所自 2014 年開始展開的 10 年計畫，特別針對由體育運動的樂趣出發達到健康促進的目的，這次研討會的主題包括：Exercise and human evolution; Joyful resistance exercise for resisting sarcopenia: based on the elderly exercise environment; Promotion of physical function and fitness of children and young adults through sport activity; Sports participation and health promotion among middle-aged and older adults; Fundamental studies for improvement of sport skills。涵蓋的領域相當廣也相當豐富。另外，第 3 屆壓力與疾病國際研討會日期在 3 月 6 日，地點剛好也在日本東京，因此可以同時參與另一場學術饗宴，大會邀請美國學者 Christopher S. Colwell 針對近幾年一連串優異的學術研究發表演講:[Circadian Disruption in Neurological Diseases: mechanisms and opportunities for interventions.]以及匈牙利學者 Zsolt Radak 發表演講:[Is physical activity an elixir against aging?]。相當精采的演說並提供了運動免疫學的研究方向與重要議題的探討。

下午則先安排壁報論文的報告者簡短的說明，讓與會人士更加容易了解並有充分的時間可以進行學術交流。隨著近幾年來大家已將運動當做預防醫學的一部份，藉由這次的參與，大會安排各個領域的研究成果壁報論文發表，研究資訊暨豐富又新穎，獲益良多。對於未來進行跨領域的研究，具有相當大的助益。

二、與會心得

感謝科技部的補助使主持人得以參加國際運動免疫相關研討會，各國運動免疫學專家齊聚一堂，不僅可以了解國際上研究之趨勢，加上個人在運動免疫的研究與發表，更可以藉此機會與各國從事運動免疫相關的研究學者交流，並建立未來國際合作之基礎。在深入了解運動免疫與健康促進發展的方向之後，對本身的研究領域專長有相當大的啟發，同時也藉由壁報論文的發表，與相關研究人員討論，有助於未來論文於國際期刊上的發表，並可提高台灣在運動免疫學方面的學術研究國際知名度。

三、建議

希望科技部繼續鼓勵與補助研究人員出國的經費，參與國際研討會的各國人數代表了該國對於研究之重視與成果卓越，讓研究人員有機會與該領域的學者進行交流與討論，另外，許多國際研討會會邀請此領域著名期刊的主編與會並進行演講，這將有助於研究者投稿時能順利獲得建議修改並被刊登。另外並可藉參與國際研討會的機會與其他國家的研究單位拓展進一步的交流機會，讓台灣的研究隨時保有國際競爭力。

The structural characteristics of green tea polyphenol on LPS-stimulated RAW cells

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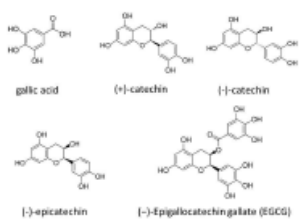
Introduction

The inflammatory response of macrophages is involved in pathogenesis of lifestyle-related diseases. Toll-like receptor 4 (TLR4) plays an important role in inflammatory response of macrophages. TLR4 is the receptor for lipopolysaccharide (LPS), a major component of the outer membrane of Gram-negative bacteria. The stimulation of LPS induced activation of TLR4 and mitogen-activated protein kinase (MAPK) pathways in macrophages, and resulting in the production of several pro-inflammatory cytokines and inflammatory mediators. On the other hand, green tea exhibits prevention of lifestyle-related diseases and anti-inflammatory effect. Green tea contains several polyphenol such as gallic acid, (+)-catechin, (-)-catechin, (-)-epicatechin and EGCG. Among green tea polyphenols, the anti-inflammatory effects of EGCG were well studied, but the anti-inflammatory effects of the other polyphenols have not been fully investigated. This study investigated the structural characteristics of green tea polyphenol including gallic acid, (+)-catechin, (-)-catechin, (-)-epicatechin and EGCG *in vitro* (Fig. 1.).



Methods

Cells and cell culture conditions: Mouse macrophage cell line RAW cells were cultured in DMEM supplemented with 10% fetal bovine serum in a humidified atmosphere of 5% CO_2 at 37°C and passaged every 2-3 days to maintain growth.
Cytokine measurement: RAW cells were seeded on 6-well plate. After 24 h, cells were pre-treated with various concentrations (0, 1 and 10 μM) of polyphenols (gallic acid, (+)-catechin, (-)-catechin, (-)-epicatechin and EGCG) for 4 h, and were stimulated with 50 ng/ml LPS for 24h. After treatment with LPS for 24 h, the supernatants were harvested. The production of TNF-α and IL-6 were measured by ELISA (R&D Systems).
Total protein analysis: Total protein of the cells was used to detect the effects of green tea polyphenols on cell growth/protien. Cells were lysed in 100 μl RIPA buffer. The whole cell lysate was used for determination of protein concentration by the micro-bicinchoninic acid (BCA) assay (Thermo Scientific), according to the manufacturer's instruction.
Western blotting: Cells were pre-treated with 10 μM of polyphenols (gallic acid, (+)-catechin, (-)-catechin, (-)-epicatechin and EGCG) for 4 h, and were stimulated with 50 ng/ml LPS for 45 min and 2 h. The production and phosphorylation of p38 MAPK were determined by Western blotting using anti-mouse p38 MAPK antibody (Cell Signaling Technology) and anti-mouse TAK-1 antibody (Cell Signaling Technology).

Results

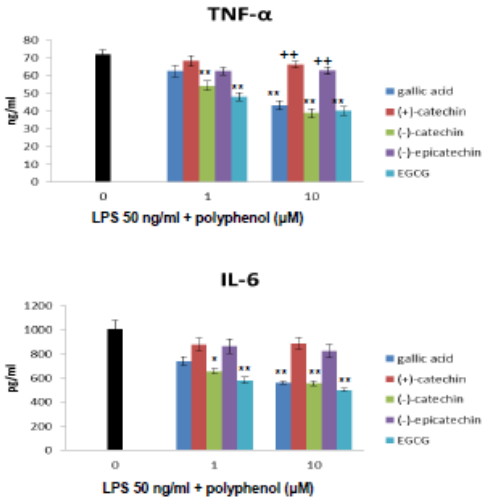


Fig. 2. The gallic acid, (-)-catechin and EGCG suppressed LPS-induced pro-inflammatory cytokine production. The Effects of polyphenols of green tea on LPS-induced TNF-α (A) and IL-6 (B) production in RAW cells. The close bar: without pretreatment with polyphenols. Each column represents the mean ± SEM from three independent experiments. *: $p<0.05$, **: $p<0.01$ versus the pre-treatment without polyphenol. +: $p<0.05$, ++: $p<0.01$ versus the same concentration of EGCG.

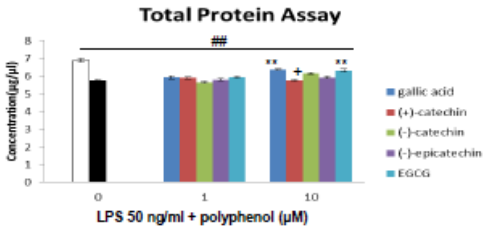


Fig. 3. The gallic acid and EGCG prevented from decreasing total protein of LPS-stimulated RAW cells. *The open bar* without polyphenols pretreatment and LPS challenge (negative control). *The close bar*: without polyphenols treatment. Each column represents the mean ± SEM from three independent experiments. ##: $p<0.01$ versus the negative control. **: $p<0.01$ versus the pre-treatment without polyphenol of green tea. +: $p<0.05$ versus the same concentration of EGCG.

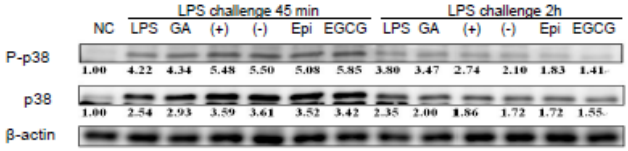
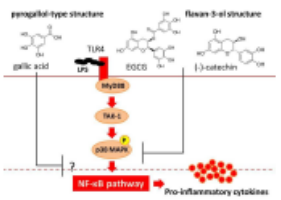


Fig. 4. The polyphenol with flavan-3-ol structure enhanced production and phosphorylation of p38 MAPK after LPS challenge for 45 min, while suppressed production and phosphorylation of p38 MAPK after LPS challenge for 2 h. NC, negative control; LPS, stimulated with LPS (50 ng/ml) and without pretreatment of polyphenol; GA, pretreatment with gallic acid for 4 h; (+), pretreatment with (+)-catechin for 4 h; (-), pretreatment with (-)-catchin for 4 h; Epi, pretreatment with (-)-epicatechin for 4 h; EGCG, pretreatment with EGCG for 4 h.

Discussion & Conclusion

Among green tea polyphenols in this study, EGCG exerted most powerful anti-inflammatory effect on LPS-induced pro-inflammatory cytokine production. The polyphenol with pyrogallol-type structure such as, gallic acid and EGCG prevented from decreasing total protein of LPS-stimulated RAW cells. Moreover, the polyphenols with a flavan-3-ol structure ((+)-catechin, (-)-catechin, (-)-epicatechin and EGCG) regulated production and phosphorylation of p-38 MAPK. On the other hand, the polyphenol with pyrogallol-type structure, gallic acid neither enhanced nor suppressed production of p38 MAPK and its phosphorylation. These results suggest that anti-inflammatory effect of gallic acid was not attributable to the production of p38 MAPK and its phosphorylation.



Certificate of Attendance

Presented to

Prof. Shih-Hua FANG

For attending the

1st International Symposium Health Promotion: The Joy of Sports and Exercise

Organized by Faculty of Sport Sciences, Waseda University

on March 4, 2015

at Higashi-Fushimi Campus, Waseda University

Kazuyuki Kanosue, Prof.
Program Leader
MEXT Top Global Project "Health Promotion: The Joy of Sports and Exercise"
Faculty of Sport Sciences,
Waseda University, Japan

Certificate of Attendance

Presented to

Prof. Shih-Hua FANG

For attending the

3rd symposium on stress responses and diseases

Organized by Waseda University on March 6-7, 2015

at Center for Advanced Biomedical Sciences, Waseda University

Shigenobu SHIBATA, Prof.
Program Leader
Department of Electrical Engineering
and Biosceince,
Waseda University, Japan

科技部補助計畫衍生研發成果推廣資料表

日期:2015/09/23

科技部補助計畫	計畫名稱: 綠茶對連續高強度運動誘發之高氧化壓力與免疫反應之調控與其分子機制探討
	計畫主持人: 方世華
	計畫編號: 101-2628-H-028-002-MY3　　學門領域: 運動生理學

無研發成果推廣資料

101年度專題研究計畫研究成果彙整表

計畫主持人：方世華	計畫編號：101-2628-H-028-002-MY3
計畫名稱：綠茶對連續高強度運動誘發之高氧化壓力與免疫反應之調控與其分子機制探討	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數（含實際已達成數）	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	1	1	100%		
國外	論文著作	期刊論文	1	1	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	1	1	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	1	1	100%		

其他成果（無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。）	無

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

科技部補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估
   ■達成目標
   □未達成目標（請說明，以100字為限）
      □實驗失敗
      □因故實驗中斷
      □其他原因
   說明：

2. 研究成果在學術期刊發表或申請專利等情形：
   論文：□已發表 □未發表之文稿 ■撰寫中 □無
   專利：□已獲得 □申請中 ■無
   技轉：□已技轉 □洽談中 ■無
   其他：（以100字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以500字為限）