Effect of Physical Activity on Executive Function during the COVID-19 Pandemic

Tan Cher Yi

Sunway University

Supervisors:

Assoc. Prof. Dr. Yong Min Hooi, Sunway University

Assoc. Prof. Dr. Alexandre Schaefer, Monash University

Introduction

ICRI – HASS
CONFERENCE
2nd - 4th June 2021

2

Background

- Physically inactive adults:
  - Global: **27.5%** (Guthold et al., 2018)
    - East and Southeast Asia: **17.3%** (Guthold et al., 2018)
    - Malaysia: **25.1%** (Institute for Public Health, 2020)

Noncommunicable diseases (Chan et al., 2017; Seong & Chan, 2018)

- Benefits of physical activity (PA) on physical and mental health ranging from:
  - Diabetes control (Jelleyman et al., 2015)
  - Anxiety and depression treatment (Aylett et al., 2018; de Oliveira et al., 2019)
  - Executive function (EF; Kamijo & Takeda, 2010; Lipowski et al., 2019; Mir et al., 2019)

3

Background

- The **COVID-19 pandemic**:
  - Movement control restriction: reduced opportunities to remain physically active (Ministry of Health Malaysia, 2020).
  - Heightened anxiety across the globe (Menzies & Menzies, 2020) including Malaysia (Tan et al., 2021).

- The reduction in PA and increased mental stress may have contributed to vulnerability in EF.

4

Executive Function

❖ EF is an umbrella term used to describe different cognitive processes which responsible for our thought, behavior and affection (Miyake et al., 2000; Miyake & Friedman, 2012).

❖ Focus of present study:
   ❖ **Attention**
   ❖ **Working Memory (WM)**
   ❖ **Cognitive Flexibility (CF)**

5

Physical Activity

• Any bodily movement controlled by skeletal muscles that requires energy expenditure (Westerterp, 2013).

Fig. 1 Examples of Physical Activity (Public Health England, 2016)

6

Physical Activity

- The amount of PA is determined by the concept of **dose** – a multidimensional construct that consists of duration, frequency, and intensity (Falck et al., 2018):

- One of the ways to classify PA intensity is based on Metabolic Equivalent (MET) – the ratio of an individual's working metabolic rate relative to the resting metabolic rate (Coelho-Ravagnani et al., 2013).

PA Group	MET minutes per week
Low	> 600
Moderate	600 – 2999
High	3000 and above

7

Methods to Quantify Physical Activity

- Objective measure:
  - accelerometers, pedometers, heart rate monitors.

- Self-reported method:
  - Questionnaire
  - **Time-based diary**

1. Provide detailed PA information.

2. Allow participants to self-report their PA regardless of location and dependency on wearables.

8

Literature Review and Research Gap

9

Effect of Physical Activity on Executive Function

- **Dose-response hypothesis**:
  - Liner relationship between PA dose and EF among healthy young adults – a greater PA dose results in a higher heart rate and cardiovascular capacity (Vouatzis et al. 2011) as well as higher elevation of brain-derived neurotrophic factor (BDNF) production i.e. important for growth and differentiation of neurons (Jeon & Ha, 2017) which then results in much improved EF performance.

10

Effect of Physical Activity on Executive Function

➤ There was a mixed response on how PA affects EF.

EF Domains	Significant effect	Non-significant effect
Attention	Huertas et al., 2011; Miñ et al., 2016	Blumenthal et al., 1989; Ekblom et al., 2019
Working Memory	Hansen et al., 2004, Cambourne, 2006; Lipowski et al., 2019	Eggermont et al., 2009
Cognitive Flexibility	Kamijo & Takeda, 2010	Patterson et al., 2018

➤ Little is known about the sustainability of these EF over time for very few included a follow-up.

    ➤ Takacs and Kassai (2019) reported that only 15% of studies had included a follow-up which ranged from 6 weeks to 12 months in their meta-analyses.

11

Research Aims and Research Hypotheses

12

Research Aims

We examined:

✓ the **effect of physical activity** (high, moderate and low PA) **on EF** (attention, working memory, cognitive flexibility).

✓ whether the effect of PA on EF **sustained** over 6 weeks in total.

13

Research Hypotheses

The hypotheses were formulated based on:

(1) dose-response in that compared to low PA group, we expected participants in high and moderate PA groups will have higher accuracy in attention and WM as well as higher CF (self-rated and task-based) at Time 2.

(2) high and moderate PA groups will also show EF improvement from Time 1 to Time 2 as well as from Time 1 to Time 3.

(3) similar performance will sustain over time in that we predicted that participants in high and moderate PA groups will have similar performance in attention, WM, and CF tasks at Time 3 compared to Time 2.

14

Method

Participants

- **105** participants (76 females, M_{age} = 25.79, SD = 3.9?, 66.70% Chinese).

PA Group	Number of participants	M_{MET}	SD
Low		170.44	170.22
Moderate	46	1647.??	587.20
High	30	3?6?.47	1033.88

- Data was collected from May 2020 to October 2020
- Recruitment: Word of mouth reference and online platforms
- Compensation: RM40 Grab food voucher

Note: After one month of PA recording, 71.74% (n = 33) from the moderate physical activity group and 90% (n = 27) from the high PA maintained similar PA to the 14-day recording.
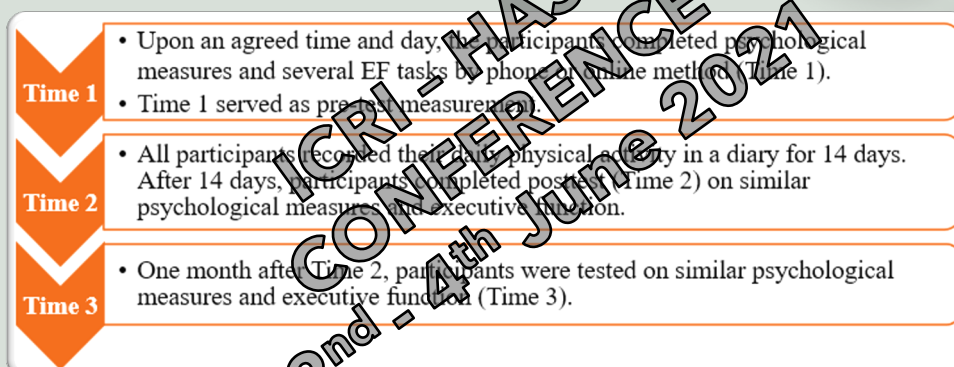
Research Design

- 3 between-subjects (PA group: high, moderate, low) x 3 within-subjects (Time of measurement: Time 1, Time 2, Time 3) mixed research design.

Measures

- Phone interview (OR online platforms e.g., WhatsApp, Zoom etc.)
  - *Attention*: Symbol Digit Modalities Test (Hinton-Bayre & Geffen, 2005)
  - *Working memory*: Digit Span Backwards (Wechsler, 1997).
  - *Cognitive flexibility*: Cognitive Flexibility Scale (Martin & Rubin, 1995) and Guilford's Alternate Uses Test (Guilford, 1967)
- Online survey:
  - Screening and demographic data
  - *Perceived Social Isolation:* Social Isolation Scale (Cotten et al., 2013)
  - *Socioeconomic status*: Scale of Subjective Status (Adler et al., 2008)
  - *Mood and Feelings:* Mood and Feelings Questionnaire (Costello & Angold, 1988)
  - *Stress:* Perceived Stress Scale (Cohen et al., 1983)
- Physical activity diary

17

Procedure

Time 1	• Upon an agreed time and day, the participants completed psychological measures and several EF tasks by phone or online method (Time 1). • Time 1 served as pre-test measurement.
Time 2	• All participants recorded their daily physical activity in a diary for 14 days. After 14 days, participants completed post-test (Time 2) on similar psychological measures and executive function.
Time 3	• One month after Time 2, participants were tested on similar psychological measures and executive function (Time 3).

18

9

Data Analysis

➤ SPSS version 25 (Hayes, 2017)

➤ 3 (PA group: high, moderate, low) x 3 (Time: Time 1, Time 2, Time 3) mixed factorial analysis of variance (ANOVA)

➤ One-way ANOVA

➤ Paired-samples *t*-test

➤ Additional analyses: one-way ANOVA and linear regression among participants from low PA group

19

Key Findings & Discussion

20

Effect of Physical Activity on Executive Function

❑ Both **high** and **moderate PA doses** (i.e., combination of PA duration, frequency, and intensity) **are equally beneficial** for **attention and WM** when compared to low PA dose after 14 days of PA recording.

❑ Our **high** and **moderate PA group had improved significantly in attention and WM accuracy after recording PA diary for 14 days** (Time 2 vs. Time 1) and **sustained over time** (Time 3 vs. Time 1). These findings are important as attention and WM accuracy are linked with skills and abilities required to solve everyday problem e.g., proofreading accuracy that affects quality of work directly (Shafto, 2015) and fluid intelligence to solve problems independent of learning and experience (Jaeggi et al., 2010). Hence, both EF domains are closely related to professional and educational success in a long run.

21

Effect of Physical Activity on Executive Function

❑ The was a **maintenance of one-month effect** from the high and moderate PA groups on attention accuracy, WM accuracy, self-rated CF, and task-based CF.
  ❑ The findings of this study contribute to the overall body of knowledge on that a culmination of intensity, type, and duration in PA leaves a longer effect on EF than previously thought.

22

Effect of Physical Activity on Executive Function

❑ Low physical activity exerted a significant detrimental effect on attention as demonstrated by our low PA group after 14 days of diary and at the end of the study period compared to baseline.
    ❑ The decline in low PA is not due to mood and feelings, stress, and perceived social isolation.
    ❑ We are however cautious with this finding as data was collected when the movement restriction was still in its early days.

23

Limitations and Future Studies:
- Most of our participants are Chinese (86.7%).
- Current study did not take account the impact of sleep on executive function.
- A longer follow-up (e.g., 2 to 12 months) and use of heart rate monitor as a supplement for PA diary.

24

Theoretical Implication:

❑ This study contributes to the understanding of **linear dose-response relationship between PA and EF** among healthy adult population.

❑ The higher the PA dose, the greater the EF performance.

Practical Implication:

❑ It's important to stay **physically active** during the pandemic to maintain high levels of EF.

❑ **Government and organizations:**

❑ Increase access for PA participation and to have more culturally sensitive facilities.

❑ **Individuals:**

❑ Virtual exercise class, stair climbing, and use of exercise alert applications.

25

Conclusion:

o Current study added new knowledge related to **sustainability effect of PA on EF** and included a more **objective form of measuring exercise virtually** by using a PA diary during the COVID-19 pandemic.

o The cognitive-training industry has spent more than $8 billion by 2021 in designing cognitive training protocols (Ahuja, 2019) and it is important to wisely select interventions or protocols with long-term benefits so that it is worth the amount of resources and time invested. Current study showed a **cost-effective way of enhancing one's EF in a long-run via involving in PA actively**.

26

Thank you!

Please contact me at

19025766@imail.sunway.edu.my

27