



## THE 2ND INTERNATIONAL SEMINAR OF MULTICULTURAL PSYCHOLOGY "BUILDING SUSTAINABLE COMMUNITIES LIVING"



# PROCEEDING

## International Seminar on Multicultural Psychology

Faculty of Psychology Universitas 17 Agustus 1945 Surabaya

14<sup>th</sup> - 16<sup>th</sup> of July 2023



Online From Faculty of Psychology Universitas 17 Agustus 1945 Surabaya

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## **The 2<sup>nd</sup> International Seminar on Multicultural Psychology**

**“BUILDING SUSTAINABLE COMMUNITIES LIVING”**

**Faculty of Psychology Universitas 17 Agustus 1945 Surabaya  
July 2023**

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## **FOREWORD**

Dr. Andik Matulesy, M.Si, Psychologist  
Head of Indonesian Psychological Association (HIMPSI)

Assalammu'alaikum Wr.Wb  
Greetings and Prosperity Om  
Swasti Astu  
Nammo Budhaya  
Greetings of Virtue  
Healthy Greetings



As an important part of implementing the Psychology Education and Services Act number 23 of 2022, cooperation between Higher Education and the Psychological Association Professional Organization is highly urgent. The collaboration includes the professional education of General Psychologists, Specialist Psychologists, and Sub- Specialist Psychologists and is equally important in improving the competence of Psychology students and graduates. In addition, disseminating information and results of studies/research from scientists and professionals in the field of psychology is an important part of improving society's psychological well-being and health.

Therefore I appreciate activity 2-nd International Seminar of Multicultural Psychology (ISMP) held by the Faculty of Psychology, Universitas 17 Agustus 1945 (UNTAG) Surabaya. This activity proves that Higher Education has a great commitment and responsibility to develop the competence of the psychology community locally, nationally, and internationally.

We hope this international seminar will run smoothly and generate new ideas for the scientific and professional development of Psychology in Indonesia, which can be implemented for the benefit of the nation and state of Indonesia.

Thankyou



## FOREWORD

Prof. Dr. Mulyanto Nugroho, MM., CMA., CPA  
Rector Universitas 17 Agustus 1945 Surabaya

The Honorable,

1. Vice Governor of East Java
2. Regent of Ngawi Regency
3. Head of Indonesian Psychological Association (HIMPSI)
4. Speakers from:
  - Universiti Pendidikan Sultan Idris Malaysia
  - Lomonosov Moscow State University Russia
  - Universitas 17 Agustus 1945 Surabaya
  - Hong Kong Psychological Society
  - Singapore Psychological Society
5. Dean of Faculty of Psychology Untag Surabaya
6. Participants International Seminar
7. Happy audience



Assalamualaikum warahmatullahi wabarakatuh,  
Shalom,  
Om Swastiastu,  
Nammo Budhaya,  
Rahayu,  
Good Morning and Peace be upon us all

Praise and gratitude to Allah SWT, we are still given health to be able to attend the 2<sup>nd</sup> International Seminar of Multicultural Psychology with the theme "***Building Sustainable Communities Living***" organized by the Faculty of Psychology Untag Surabaya.

In the midst of the development of science and technology, the demands of life continue to increase and bring us to various differences in focus and goals. Humans who are created with various differences, are still faced with various demands of differences to survive. Both cultural differences, differences in points of view and even differences in beliefs. But actually, a healthy human being is a human being who can still benefit others despite being between many differences.

Psychology as a behavioral science, is one of the fields of science that is needed to educate many people to still have a healthy mentality to be resilient to undergo various demands, changes and differences in life. The international seminar held today

is expected to be the right discussion forum to develop knowledge and bring up various ideas and efforts, for the benefit of life for others.

Today, our era has changed. An era where technological progress is very rapid. Humans benefit greatly from these advances. But on the other hand, these advances also make humans complacent with the conveniences provided. We feel it too. Prefer instant things, spend more time with the digital technology we have and become less sensitive socially and things around. Psychology should be a counterweight in the current era. Maintaining good relationships with others, providing strategies that can improve human psychological well-being in the face of this instant era. With the holding of this activity, hopefully we always remember and be able to implement our knowledge as well as possible for better survival.

Ladies and gentlemen,

On behalf of Universitas 17 Agustus 1945 Surabaya, I would like to welcome all speakers and to all participants of the International Seminar. Your contributions are invaluable. Hopefully next time we can meet directly at Merah Putih Campus, Untag Surabaya. We are waiting for your presence in the city of Heroes, the city of Surabaya which has a beautiful variety of cultures, so it will not be easy to forget.

On this occasion, I would like to thank all the committees who have worked hard for the organization of this seminar. Continue to work to contribute to the nation and the world.

Finally, I congratulate you on attending the 2<sup>nd</sup> International Seminar of Multicultural Psychology with the theme "Building Sustainable Communities Living". May God Almighty be pleased and strengthen us to continue to face all our work. That is my remarks.

Thanks.

Wabillahi taufik wal hidayah, wassalamu'alaikum wr.wb.

Om Shanti Shanti Shanti Om, Namoh Buddha, Rahayu, May God Bless us all.

## FOREWORD

Dr. Rr. Amanda Pasca Rini, M.Si, Psychologist  
Dean of  
Faculty of Psychology  
Universitas 17 Agustus 1945 Surabaya

Assalammu'alaikum Wr.Wb  
Greetings and Prosperity Om  
Swasti Astu  
Nammo Budhaya  
Greetings of Virtue  
Healthy Greetings



This 2<sup>nd</sup> International Seminar of Multicultural Psychology (ISMP) activity is a routine activity carried out by the Faculty of Psychology, Universitas 17 Agustus 1945 Surabaya. This seminar is an important part of the responsibility in the development of psychology science and profession in the national and international. As with the first ISMP activity, this activity was attended by psychology figures from various countries.

I would like to express my infinite gratitude to all the major Keynote Speakers **Dr. H. Emil Elestianto Dardak, B.Bus., M.Sc** and **H. Ony Anwar Harsono, S.T., M.H**, and the keynote speakers from various countries:

1. Dr. Anna Leybina
2. Dr. Austin Tay
3. Dr. Adrian Toh
4. Dr. rer.nat. Nurul Ain Hidayah bint Abas,

for their willingness to share knowledge and experience related to science and psychology profession.

I also express my appreciation to the invited speakers in the workshop:

1. Prof. Dr. Nurussakinah Dualay, M.Psi. , Psychologist
2. Prof. Dr. Fendy Suhariadi, M.T. , Psychologist
3. Dr. Ferry Wirawan Tedja, M.Psi
4. Drs. Asep Haerul Gani, Psychologist
5. Indra Y Kiling, MA., PH.D,

which is expected to be able to provide discourse on psychological implementation in the fields of organizational, educational, clinical and social industrial science. To the seminar participants, hopefully this activity will be a discussion space that can improve competence in the field of psychology as expected.

I also give appreciation to the entire committee who have tried hard to actualize this international seminar activity. Happy seminar and see you again in the third ISMP activity in 2025.

Thankyou

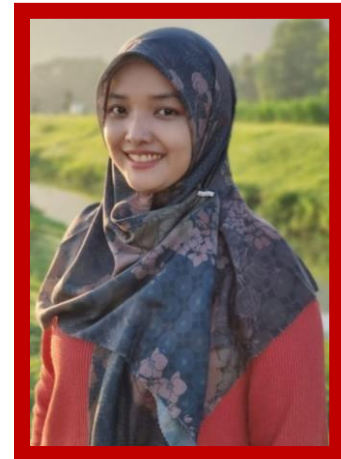


## FOREWORD

Sayidah Aulia'Ul Haque, M. Psi., Psychologist  
Chairman of ISMP 2023

Greetings,

Praise be to God for the blessing of His Grace, 2<sup>nd</sup> International Seminar of Multicultural Psychology (ISMP) can be held. I also would like to convey many thanks to the honorable:



1. Rector Universitas 17 Agustus 1945 Surabaya
2. Dean of Faculty of Psychology Universitas 17 Agustus 1945 Surabaya
3. Keynote speakers: Dr. H. Emil Elestianto Dardak, B.Bus., M.Sc., and H. Ony Anwar Harsono, S.T., M.H
4. Invited speakers:
  - a. Dr. Anna Leybina, M.Sc.Psychology, Ph.D (Lomonosov Moscow State University)
  - b. Dr. Adrian Toh (Singapore Psychological Society)
  - c. Dr. Austin Tay (Omnipsi Consulting)
  - d. Associate Prof. Dr. Rer. Nat. Nurul Ain Hidayah Binti Abas (Universiti Pendidikan Sultan Idris Malaysia)
  - e. Dr. Mamang Effendy, M. Psi (Universitas 17 Agustus 1945 Surabaya)
  - f. Dr. Bawinda Sri Lestari, M. Psi (Universitas 17 Agustus 1945 Surabaya)
  - g. Dr. Devi Puspitasari., M. Psi., Psikolog (Universitas 17 Agustus 1945 Surabaya)
5. Workshop speakers:
  - a. Prof. Dr. Fendy Suhariadi, MT., Psychologist (Universitas Airlangga Surabaya)
  - b. Prof. Dr. Nurussakinah Daulay, M. Psi., Psychologist (Universitas Islam Negeri Sumatera Utara)
  - c. Dr. Ferry Wirawan Tedja, M. Psi (CEO Samahita Wirotama)
  - d. Indra Y. Kiling, MA., Ph. D (Universitas Nusa Cendana)
  - e. Drs. Asep Haerul Gani, Psychologist (Human Capital Coach)
6. To all ISMP team members who have worked hard. I'm proud of my team. You all are really great and dedicated.

Welcome to our campus, Universitas 17 Agustus 1945 (UNTAG), Surabaya. This ISMP is the second international seminar that we held. These activities include seminars, paper presentations, scientific publication and workshops. The total is 161 people with 64 papers to be presented.

Last, I hope you can enjoy the series of events, and gain insight into sustainablecommunity living in a psychological setting. I would like to say once more on behalf ofthis seminar organizer, welcome. It is great to see so many of you here.

Best Regards,  
Sayidah Aulia'Ul Haque, M. Psi., Psychologist

## TABLE OF CONTENT

|    |   |         |
|----|---|---------|
| 1  | <b>Towards A Sustainable Campus: Study of Pro-Environmental Behavior of Canteen Traders at XYZ Private University</b><br>Yovita Ramos M., Taufik Akbar Rizqi Yunanto  | 1-12    |
| 2  | <b>Gender Differences in the Intention to Quit Smoking Among Emerging Adult: An Indonesian Context</b><br>Vania Ardelia   | 13-19   |
| 3  | <b>Analysis of Student Well-Being in Students and College Students</b><br>Ditta Febrieta, Annisa Dhani Rahmawati, Tasya Aulia Adzani  | 20-29   |
| 4  | <b>Victims of Verbal Sexual Harassment: Self-Acceptance Influence Happiness</b><br>Salsabila Ratu Kencana Syaharani, Amherstia Pasca Rina, I.G.A.A Noviekayati  | 30-37   |
| 5  | <b>The Dynamics of Resilience in Adolescent Victims of Bullying</b><br>Stefani Virlia, Jatie K. Pudjibudojo, Soerjantini Rahayu   | 38-45   |
| 6  | <b>Adaptive Leadership Model: A Systematic Literature Review and Future Research</b><br>Wahyu Eko Pujiyanto, Sayidah Aulia'ul Haque, Sutama Wisnu Dyatmika, Ferry Wirawan Tedja   | 46-61   |
| 7  | <b>About Things That Can Never be Fully Yours: A Preliminary Experiment on Flexing</b><br>Cleoputri Yusaini, Muhammad Haikal Azaim Barlaman, Jeremy Alexander Timothy   | 62-67   |
| 8  | <b>Prosocial Behavior in Adolescents: in Terms of Peer Social Support and Self Concept and Gender</b><br>I Gusti Ayu Agung Noviekayati, Amherstia Pasca Rina, Abizah Ardeillia  | 68-75   |
| 9  | <b>Effectiveness Of Landslide Disaster Education For 6th Grade Elementary School Students In SDN Galendowo, Jombang District</b><br>Yulia Vicarista Lengu, Inas Zahra, Putri Aisyah Pahlawani, Rany RD, Andik Matulesy            | 76-78   |
| 10 | <b>Love the earth and Be Happy : Landslide Response Psychoeducation</b><br>IGAA Noviekayati, Dini Novita, Miranda Abbas, Nia Aulia Lestari, Sri Wahyuni Sukri   | 79-84   |
| 11 | <b>Improving Emotional Intelligence with Emotional Management Training for Teachers of Special School</b><br>Ferrensia Octaviani, Endang Widyorini  | 85-91   |
| 12 | <b>Nutritional Status and Working Memory in Children: Physical Activity as a Mediator</b><br>Dita Kharisma Meilanawati, Endang Widyorini  | 92-100  |
| 13 | <b>Exclusionary Time Out Technique to Improve Parents of Children with Autism' Knowledge to Manage Tantrums</b><br>Luh Gede Ari Widiastuti, Endang Widyorini  | 101-108 |
| 14 | <b>Experiential Learning Method to Increase Knowledge of Landslide Disaster Mitigation</b><br>Latifatul Chariroh, Jessica Rahardja Sugiharto, Rizky Amelia Utomo, Eko Setiawan, Anrilia Ema M. Ningdiyah                          | 109-114 |
| 15 | <b>Psychoeducation on Environmental Love and Landslide Disaster Preparedness for 5th Grade Students at SDN 2 Galengdowo, Galengdowo District</b><br>Diah Sofiah, Nindya Ayu Safitri, Yogi Utomo, Catur Prasetianingsih            | 115-122 |
| 16 | <b>EFT Psychoeducation Program to Reduce Anxiety Levels in PLWHA</b><br>Ervina Kumalasari, Siswanto, Alphonsus Rachmad Djati Winarno  | 123-133 |
| 17 | <b>Construction of Career Maturity Measuring Instruments in Students</b><br>Ahmad Malik Febrianto, Dwi Rady Saputro, Ramdhan Surya Saputra, Abdul Karim, Qanisa Difanty Radhiyya Bustomi, Aji Resita Salsadila, Khalwatia Safitri | 134-142 |
| 18 | <b>Attachment to Parents and Emotional Regulation with Bullying Behavior in Students at School</b>  | 143-154 |

|    |   |         |
|----|---|---------|
|    | Rossyan Kumalasari, Rr. Amanda Pasca Rini, Sahat Saragih  |         |
| 19 | <b>Psychological Well-Being of Student Cat Owners: Is There A Role for Pet Attachment and Emotion Regulation?</b><br>Moch. Ali Masyhuri, Sahat Saragih, Yanto Prasetyo  | 155-162 |
| 20 | <b>Parenting Stress as a Mediator Between Maternal Parenting Self-Efficacy and Adaptive Behavior of Children with Intellectual Developmental Disorder</b><br>Lintang Hari Tanhanasashi Purnama, Christin Wibhowo, Erna Agustina Yudiati               | 163-172 |
| 21 | <b>The Quality of Child Parent Relationship: One of Factor Homosexuality Tendencies</b><br>Rohmat Hidayat Abdulloh, Akta Ririn Aristawati, Herlan Pratikto  | 173-180 |
| 22 | <b>The Mediating Role of Learning Agility on The Relationship Between Transformational Leadership and Innovative Work Behavior</b><br>Ainun Rosidah Diana Sofyan, Kristiana Haryanti  | 181-190 |
| 23 | <b>Reducing Child Aggressivity Through Dakon Traditional Games: Literature Review</b><br>Retno Sri Handayani  | 191-197 |
| 24 | <b>Lack of Self-Discipline in Students: A Study on How to Improve Self-Discipline in Students in the Blended Learning Process</b><br>Benedictus Surya Dharma, Augustina Sulastri, Basilius Oda Sanjaya  | 198-206 |
| 25 | <b>Psychoeducation Improves Knowledge of Love for the Environment and Landslides</b><br>Pris Arie Wibowo, Pandi Nurhadi, Shofiatul Maulidiyah, Dwi Sandy K, Amanda Pasca Rini   | 207-210 |
| 26 | <b>SETS Instrument: To Investigate Statistic Teaching Self Efficacy</b><br>Nisraeni, Riyadi, Dinny Devi Triana  | 211-217 |
| 27 | <b>The Relationship Between Self-Forgiveness and the Tendency of Self-Injury Behavior in Adolescents</b><br>Indah Pradipta Acintya Fatah  | 218-222 |
| 28 | <b>The Relationship Between the Intensity of Tiktok Social Media Use and Learning Motivation in Class XII Students</b><br>Rida Sinta Anggiandari  | 223-228 |
| 29 | <b>Development of the Social Emotional Learning Questionnaire for Students of Mathematics Education</b><br>Wirda Hayati, Wardani Rahayu, Iva Sarifah  | 229-239 |
| 30 | <b>Suicidal Ideation in Early Adult Women: Examining the Role of Emotional Maturity and Forgiveness</b><br>Annisa Nur Fadillah, Herlan Pratikto, Suhadianto   | 240-249 |
| 31 | <b>Resilient, Disaster-Responsive Children: Psychoeducation on Landslide Preparedness to Enhance Students' Knowledge</b><br>Maria Ardhita Mahayu Pramesti, Zuli Intan Rohmawati, A. Sulthanil Awliya, Livia Natania Setiawan, Tatik Meiyuntariningsih | 250-254 |
| 32 | <b>Multivariate Analysis of Critical Consciousness on Female University Students in West Java</b><br>Ibnu Athoilah, Neneng Tati Sumiati, Mohamad Avicenna, Rena Latifa, Risatianti Kolopaking   | 255-271 |
| 33 | <b>Empathy Therapy Reduces Bullying Behaviour</b><br>Ahmad Bahtiar, Suroso, Muhammad Farid  | 272-278 |
| 34 | <b>Madura Community Empowerment Through the Use of Local Culture</b><br>Yuriadi, Norsuhaily Abu Bakar   | 279-286 |
| 35 | <b>How Organizational Citizenship Behavior on Teachers Seen from Work-Life Balance and Job Satisfaction?</b><br>Rosymar Nazari Abdullah, Diah Sofiah, Yanto Prasetyo  | 287-290 |

|    |   |         |
|----|---|---------|
| 36 | <b>Correlation Perception of Workload and Emotional Regulation with Work Stress in Teachers</b><br>Derry Heryandini, Suroso, Muhammad Farid   | 291-298 |
| 37 | <b>Self-Forgiveness's Role in Addressing Low Life Meaning and Self-Harm Urges in Emerging Adults</b><br>Tatik Meiyuntariningsih, Akta Ririn Aristawati, Chelsya Sania Diani Hasri                       | 299-304 |
| 38 | <b>Moderation of Religious Communities That Have Intergenerational Relationships</b><br>Eka Zariatul Khumairoh Kelvin, Sephia Dwi Fitanti, Nur Aziz Afandi, Rini Risnawita Suminta                      | 305-312 |
| 39 | <b>Level Analysis Self-Diagnosis in The Early Adult Age Range</b><br>Eva Rizkika, Desi Fitriana, Tatik Imadatus Sa'adati, Nur Aziz Afandi   | 313-318 |
| 40 | <b>Ki Ageng Suryomentaram's Concept of Mawas Diri in Psychology: A Review</b><br>Maria Ardhita Mahayu Pramesti, Livia Natania Setiawan  | 319-325 |
| 41 | <b>Preserving Madurese Language, Is It Important?</b><br>Yudho Bawono, Wasis Purwo Wibowo   | 326-332 |
| 42 | <b>Choose: Big Salary or Work Life Balance?</b><br>Muhammad Ghazali Bagus Ani Putra   | 333-341 |
| 43 | <b>A Phenomenological Study of Grit Among Teachers in Remote Areas</b><br>Aderiko Prasetya, Amherstia Pasca Rina, Dwi Sarwindah Sukiati   | 342-349 |
| 44 | <b>The Dementia Health Literacy Intervention For Informal Caregivers: A Systematic Review Protocol</b><br>Andrian Liem, Yulisna Mutia Sari, Sharuna Verghis, Philip A. Rozario, Maw Pin Tan, Tin Tin Su | 350-361 |
| 45 | <b>Loneliness, Parent-Child Relationship and Gadget Addiction</b><br>Florentina Ratna Pradhita, Endang Widyorini  | 362-368 |
| 46 | <b>First-Then Visual Support Technique To Increase Teacher's Knowledge In Reducing Aggressive Behavior</b><br>Yumna Stia Putri Wistiani, Endang Widyorini   | 369-375 |



# Nutritional Status And Working Memory In Children: Physical Activity As A Mediator

Dita Kharisma Meilanawati<sup>1\*</sup>, Endang Widyorini<sup>2</sup>

<sup>1,2</sup> Faculty of Psychology, Soegijapranata Catholic University, Semarang, Indonesia

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## ABSTRACT

Working memory is a component of executive function that plays an important role in processing, using, and remembering information on a daily basis also known as an important predictor of future cognitive functions and school achievement. Previous research found that nutritional status could not be the only factor that significantly correlated to working memory. Therefore, research that describes the role of physical activity as a mediator in both variables is needed. This research aims to investigate how physical activity becomes a mediator between nutritional status and working memory. This research was conducted on 79 children aged 10 – 12 years old. The instruments used were Digit Span Test, Physical Activity Questionnaire for Children and Body Mass Index Measurement. The Hayes' PROCESS mediation test was used to analyze the data. The result shows that physical activity mediates the relationship between nutritional status and working memory by 15% (0.1576;  $p < 0.05$ ; 95% CI [0.0394, 0.3365]). According to the findings of the research, physical activity was proven to play the role of a mediator in relation to nutritional status and working memory.

**Keywords:** Nutritional Status; Physical Activity; Working Memory

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## INTRODUCTION

The issue of memory such as the limited retention of sensory input and incomplete absorption of information acquired through the learning process, is a commonly encountered challenge that disrupts children' learning process. Some student are quick to remember lessons they get. However, a significant number of school-age children face challenges in absorbing learning materials and having to repeat learning materials several times to remember. The prevalence of children with low working memory is estimated at 15%, and 80% of these children experience difficulties in academic areas (Wiguna et al., 2012). The survey conducted by Purnamasari, et al (2023) also found that student in grade 5 have difficulties in retaining academic lessons, including to memorizing mathematic formulas.

Children's ability to retaining academic lessons, count and complete cognitive tasks are strongly associated with working memory capacity. Working memory is a component of children's neurodevelopment and important predictor of future cognitive functions and school achievement (Fitamen et al., 2019). Working memory is type of memory defined as the capability to keep small amount of information in limited short time, that is important to children in order to develop executive function that contribute to school achievement, such as solve problem effectively, remember number in mathematics, combine words in reading (Nugroho et al., 2023). Various factors cause working memory' problem such as genetic, nutritional status, physical activity, biochemical damage in brain,

environmental pollution, social-psychological disorder. However, most common lifestyle problems among children and adolescent include inappropriate nutrition and insufficient physical activity (Slowik et al., 2019).

Indonesia as a developing country is experiencing multiple nutritional problems. Riskesdas (2013) data shows that the nutritional status of children in Indonesia aged 5-12 years (according to BMI/A) is at an underweight prevalence of 11.2%, consisting of 4% extremely underweight and 7.2% underweight. The national prevalence of overweight among children is also high at 18.8%, consisting 10.8% overweight and 8.8% obesity. Optimal nutrition during childhood is necessary for normal brain development of children since it is an important period for the formation of the brain, laying the foundation for the development of cognitive, motor, and socio-emotional skill throughout their life (Kabero et al., 2021).

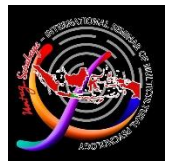
Poor nutrition and overnutrition during early period can result in a long lasting physical and mental impairment by affecting the structural and functional development of the brain. Consequently the performance of the children who had earlier suffered from malnutrition was clearly inferior to that of children who had not gone through malnutrition, which results in inferior school performance and low level of working memory (Hunt, 2005). Malnourished children with poor physical growth perform poorly in intelligence test and emphasized that malnutrition during childhood can lead to irreversible impairment of mental and cognitive function in later life (Fernstrom et al, 2001; Kamath, 2017). Not only malnutrition, numerous studies also linked obesity to poorer academic performance, memory performance, and impairment in decision making.

Obesity occurs as a result of extreme escalation in body's fatty mass percentage the muscle mass when the proportion of height to weight surpasses the optimum level, that can be caused by lack of physical activity (Alhazmi et al., 2021). Recent studies have suggested that physical activity is associated with not only chronic diseases prevention, but also cognitive and brain health (Kamijo et al., 2011). According to data from the WHO (2017) it was found that 81% of children are physically inactive. These children tend to prefer sedentary activities such as spending hours on the internet accessing social media, watching videos, playing games, and engaging in social media activities. The low level of physical activity has an impact on cognitive function, such as working memory, learning motivation, and concentration that can lead to difficulties in processing new information, and if this persist, it can result in academic achievement (Nadira & Daulay, 2021).

Physical inactivity is a significant risk factor for cardiovascular disorders and a broad spectrum of chronic diseases comprising obesity, diabetes mellitus, hypertension, osteoarthritis, osteoporosis, and depression (Warburton et al., 2006). Both lack of physical activity and its excess have a negative effect on the nutritional status, which most common nutritional abnormalities include malnutrition and overweight or obesity. The benefits of healthy eating are for increasing children' cognition, such as executive function, attention, working memory, concentration, and academic proficiency maybe moderated by physical activity.

The previous research conducted by Mamrot & Hanc (2019) it was found that there is an inverse relationship between nutritional status and executive function (EF) performance, higher BMI or nutritional status (obesity) is associated with poorer EF performance including working memory. BMI in obesity was found to be associated with decreased frontal and limbic gray matter volume (Alosco, 2014). Ruiz et al. (2010) reported that physical activity during leisure time positively influenced EF performance. Therefore, physical activity plays a crucial role in preventing excessive weight gain and optimizing working memory.





Most study examining relationship between nutritional status and physical activity on working memory in children and adolescents that described information on the strength of the association between variables separately yielded inconsistent findings. The discrepancies indicate that testing the relationship of variables separately between nutritional status and working memory, as well as physical activity and working memory may not be able to reveal the complex association between nutritional status and physical activity on working memory due to the interdependencies among these variables. Notably, the correlation between nutritional status and physical activity underscores the need to view them as holistic concept that influences working memory in children. Therefore, research that describes the role of physical activity as a mediator in both variables is needed

## METHODS

### Research Design

A quantitative correlational method was used in this research to investigate the relation between the three examined variables: Nutritional Status, Working Memory, and Physical Activity. The data were taken direct to participant who fit with the criteria for this research using several instrument: Digit Span Test, Physical Activity Questionnaire for Children and Body Mass Index Measurement. Prior to the research, all participants were given a chance to give their consent in an Informed Consent form.

### Participants

The populations in this research were all 134 students in grade 4, 5, and 6 at SD N X Lampung Timur. The participants in this research were selected by non-probability sampling method, the sampling technique used by the researcher was purposive sampling because there were certain considerations for sampling. These criteria are children in grades 4, 5, and 6 aged 10-12 years. Sudarmawan (2013) argued that children aged 10-12 years have a fairly high level of understanding, so the child can take the test properly.

The participants used in this research is 79 students consisting 50,6% (40) female participants and 49,4% (39) male participants aged 10-12 years.

### Instruments

Three research instruments were used in this research:

*Digit Span Test:* The instrument was to measure working memory in children. This test is one of the subtests in the WISC test created by David Wechsler. There are two parts of the digit span test; digit span forward and digit span backward. Each parts of the test consist seven numeric items starting at three to nine (forward) or two to eight (backward). In the digit span forward test, the participants is instructed to repeat a series of number mentioned by examiner sequentially from front to back, whereas in the digit span backward test participants repeats from last number to the first number mentioned by examiner (from back to front). The scoring system is by adding up the last series that were successfully repeated by the participants in both tests (forward and backward). This test has high reliability across all age ranges with a coefficient of 0.77-0.86 (Dison, 1893) and construct validity for this test has stabilized (Kush and Watkins, 1997).

*Physical Activity Questionnaire for Children:* Physical activity as the mediator variable in this measured using the physical activity questionnaire, which was developed by Kowalski et al (2004) is a seven-day recall self-administered questionnaire to assess general levels of physical activity throughout

the elementary school year for student in grades 4 to 8 and approximately 8-14 years of age. The PAQ-C can be administered in classroom settings and provides summary physical activity score delivered nine items, each scored on a 5-point scale starting from 1 “very low activity” to 5 “high activity”. After having scores from 1 to 5 for each items (items 1 to 9) used in the physical activity composite score, take the mean of these 9 items to get the PAQ-C result. The item scale correlations on this instrument were all above 0.30, and the scale reliability was acceptable for both females (0.83) and males (0.80) (Kowalski et al, 2004).

*Body Mass Index Measurement:* BMI is the most popular and common method for nutritional status assessment. BMI is calculated of body weight in kilograms divided by height in meters squared. In the case of children, the interpretation of nutritional status should compare BMI values with norms, it is recommended that BMI standard deviation z-score, age, and gender are considered to determine the classification of nutritional status.

### **Research Procedure**

The research was a cross-sectional study. Prior to the tests, preliminary studies were conducted to collect profiles of children to exclude ineligible participants (under 10 years and over 12 years). Data were collected at school on the same day. The first measurement is BMI, participants’ weight and height were collected barefoot and lightly clothed. The digit span test is carried out afterward, the children are tested one by one. The last measurement is the PAQ-C questionnaire which is filled in directly by the participants.

### **Data Analysis**

The acquired data in this research were processed using an IBM SPSS for Statistics 22 and The Hayes’ PROCESS. Three main variables will be analyzed in this research, Nutritional Status as the independent variable, Working Memory as the dependent variable, and Physical Activity which is expected to play the mediating role in the relationship between independent and dependent variables. To test the hypotheses, the researchers use The Hayes’ PROCESS with the help of IMB SPSS for Statistics 22. It was expected that physical activity takes the mediating role in the relationship between nutritional status and working memory; whether the mediating effect was partial or complete mediation also be investigated statistically. Before conducting the analysis, the normality of the items and the scale were checked and the data is normally distributed

## **RESULT**

### **Participant’s Characteristic**

In this research, 79 students were selected as participants consisting 50,6% (40) female participants and 49,4% (39). This research characteristic participants are children in grades 4, 5, and 6 aged 10-12 years.

### **Data Analysis**

Researcher used PROCESS to test the hypotheses, the role of physical activity towards the correlations between nutritional status and working memory in children. Detailed explanations regarding the path of the role of each variable can be seen in Fig.1 and Fig.2 :

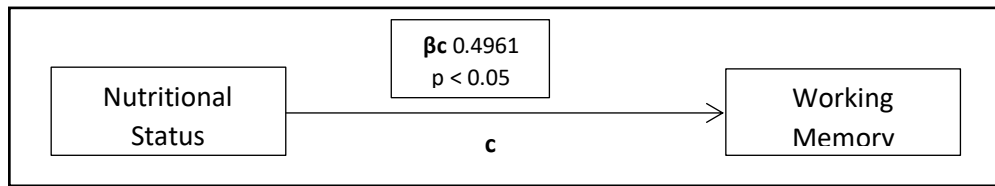


Figure 1.

The Relationship between Nutritional Status, Physical Activity, and Working Memory  
 Note:  $\beta_c$  =  $\beta$  coefficient between dependent and independent variables (total effect)

As depicted in Figure 1, the total effect of collectivism was significant with  $\beta_c = 0.4961$ ,  $SE = 0.136$ ,  $p = 0.0005$ , 95% CI (0.2244, 0.7678). This indicates a significant and positive relationship between nutritional status and working memory. These result demonstrate that a child's nutritional status plays a crucial role in determining their working memory abilities. Therefore, an enhanced nutritional status is associated with improved working memory in children.

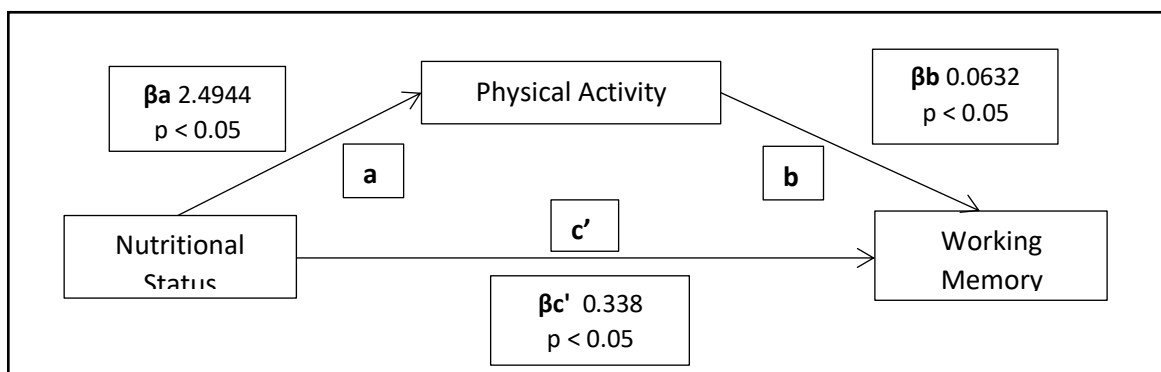


Figure 2.

Path Analysis Diagram between Nutritional Status, Physical Activity, and Working Memory  
 Note:  $\beta_{c'}$  =  $\beta$  coefficient between dependent and independent variables (direct effect);  $\beta_a$  =  $\beta$  coefficient between dependent variable and mediator;  $\beta_b$  =  $\beta$  coefficient between mediator and independent variable.

As depicted in Figure 2, path **a** represents the relationship between nutritional status and physical activity. There is a significant and positive relationship between nutritional status and physical activity with  $\beta_a = 2.4944$ ,  $p = 0.0019$  ( $p < 0.05$ ). This indicates that a higher nutritional status is associated with increased levels of physical activity in children.

Path **b** represents the relationship between physical activity and working memory. There is a significant and positive association between physical activity and working memory with  $\beta_b = 0.0632$ ,  $p = 0.0013$  ( $p < 0.05$ ). This indicates that an improve level of physical activity are associated with enhanced working memory in children.

Path **c'** represents the direct effect, which is the relationship between nutritional status and working memory mediated by physical activity. The analysis shows a significant result with  $\beta_{c'}$  =

0.3385, SE= 0.1365, p= 0.0154 (p<0.05), 95% CI (0.0666, 0.6104). The effects of physical activity are summarized in Table 1 below.

Tabel 1. Direct, indirect, and total effect between Nutritional Status and Working Memory on Physical Activity

| Relationship  | Total Effect | Direct Effect | Indirect Effect | Confidence Interval |             | Conclusion        |
|---|--------------|---------------|-----------------|---------------------|-------------|-------------------|
|   |              |               |                 | Lower Bound         | Upper Bound |                   |
| Nutritional Status →<br>Physical Activity →<br>Working Memory | 0.4961       | 0.338         | 0.1576          | 0.0394              | 0.3365      | Partial Mediation |

The subsequent findings is the indirect effect pathway, revealing the magnitude of the mediator’ role, as depicted in table 1. The result shows that physical activity mediates the relationship between nutritional status and working memory by 15% (0.1576; p<0.05; 95% CI [0.0394, 0.3365]). According to the findings of the research, physical activity was proven to play the role of a mediator in relation to nutritional status and working memory. Hence, physical activity partially mediated the relationship between nutritional status and working memory.

## DISCUSSION

The research examines three variables; nutritional status, working memory, and physical activity as mediator. The main hypothesis of this study is to investigate the role of physical activity as a mediator towards the relationship between nutritional status and working memory. The higher levels of physical activity in children will lead to an optimization of nutritional status, which in turn plays a role in enhancing working memory. The result shows that physical activity mediates the relationship between nutritional status and working memory by 15% (0.1576; p<0.05; 95% CI [0.0394, 0.3365]). That means that 85% of the variance in working memory can be attributed to other factors related to working memory such as genetic, lack of oxygen due to brain injury, biochemical damage in brain, environmental pollution, social-psychological disorder (Slowik et al., 2019).

These findings are supported by previous research conducted by Alhazmi et al. (2021) which state that regular physical activity is associated with weight loss and overall health that affect in cognitive capabilities. Participants with normal weight did a higher level of physical activity than overweight student, which in turn enhances their academic performance. A positive relationship between physical activity (PA) and memory in elementary school student was suggested in previous research conducted by Sibley & Etnier (2003), the psychological mechanisms suggested to elucidate the association between physical activity and memory include the following: (1) exercise may increase cerebral blood flow to increase the supply of glucose and oxygen to the brain; (2) both acute and chronic exercise may influence neurotransmitter levels with potential effects on memory and psychological state, and (3) exercise may increase the vasculature in the cerebral cortex and reduce vascular diffusion distance (Etnier et al., 1997). Therefore, physical activity is beneficial in optimizing the influence of nutritional status on working memory.



Another finding from this research is there was a positive correlation between nutritional status and working memory both directly and after being mediated by physical activity. Hence, physical activity partially mediated the relationship between nutritional status and working memory. The study conducted by Purnamasari et al. (2023) also found that there was a positive correlation between nutritional status and short term memory which includes working memory. The better nutritional status of student, the higher their memory. Children with malnutrition experience limited memory, productivity, and learning achievement. Malnutrition will affect the formation of neuropsychology and neurochemistry of the formation of the hippocampus (Rachmawati et al., 2021). Hippocampus is thought to have a crucial role in determining brainpower in capturing and storing memories.

The research conducted by Alhazmi et al. (2021) found different result that nutritional status (BMI) was significantly negatively correlated with BMI among student. Mamrot & Hanc (2019) also found that there is an inverse relationship between nutritional status and executive function (EF) performance, higher BMI or nutritional status (obesity) is associated with poorer EF performance including working memory. Laurent et al. (2020) states that from neurophysiological perspective, high BMI (overweight or obesity) is significantly related to low cortical thickness of eighteen cortical regions and decreased frontal and limbic gray matter volume. These suggest the possibility of poorer executive function performance including working memory. Hence, an optimal working memory can be achieved by maintaining a balanced nutritional status (neither deficient nor excessive also known as underweight or overweight). This necessitates the involvement of physical activity as a mediating factor in the process.

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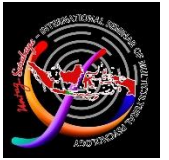
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