Six weeks of therapeutic exercise program improves locomotor of intellectual disability

Seis semanas de programa de ejercicio terapéutico mejoran la locomoción en discapacidad intelectual

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Abstract

Introduction: Locomotor skills in individuals with intellectual disabilities are often underdeveloped, affecting their functional independence and quality of life. Physical exercise programs, particularly those that are therapeutic and structured, are increasingly recognized as effective interventions to address these deficits.
Objective: The study investigated the effect of six weeks of therapeutic exercise program to improve locomotor of intellectual disability
Methodology: A quasi-experimental design with pre-test and post-test was employed. Eight students with intellectual disabilities voluntarily participated in the study, with informed consent obtained from their parents. The intervention consisted of six weeks of structured exercises (plank, sit-ups, push-ups, skipping, and jumping jacks), conducted three times per week for 60 minutes per session. Data were analyzed using paired t-tests and independent t-tests, with a significance level set at $p < 0.05$ and effect size measured using Cohen's d.
Discussion: Significant improvements were observed in jumping ($t = -2.979$, $p = 0.021$, $d = -1.053$), push-ups ($p = 0.041$), and plank ($p = 0.041$) after the intervention. No significant differences were found between males and females ($p > 0.05$). The results highlight the program's effectiveness in enhancing locomotor performance and core strength in students with intellectual disabilities.
Conclusion: The six-week therapeutic exercise program proved effective in improving locomotor abilities, particularly jumping and core strength, among students with intellectual disabilities. Regular, simple physical activities are recommended to support continuous development and injury prevention in this population.

Keywords

Exercise therapy; skipping; jumping; intellectual disability.

Resumen

Introducción: Las habilidades locomotoras en personas con discapacidad intelectual suelen estar subdesarrolladas, lo que afecta su independencia funcional y calidad de vida. Los programas de ejercicio físico, especialmente aquellos que son terapéuticos y estructurados, son cada vez más reconocidos como intervenciones eficaces para abordar estas deficiencias.
Objetivo: Este estudio tuvo como objetivo investigar los efectos de un programa de ejercicio terapéutico de seis semanas sobre la mejora de las habilidades locomotoras especialmente el salto y la cuerda en estudiantes con discapacidad intelectual.
Metodología: Se empleó un diseño cuasi-experimental con pretest y postest. Ocho estudiantes con discapacidad intelectual participaron voluntariamente en el estudio, con el consentimiento informado de sus padres. La intervención consistió en seis semanas de ejercicios estructurados (plancha, abdominales, flexiones, saltos de cuerda y jumping jacks), realizados tres veces por semana durante 60 minutos por sesión. Los datos fueron analizados mediante pruebas t pareadas e independientes, con un nivel de significancia de $p < 0.05$ y el tamaño del efecto medido con d de Cohen.
Discusión: Se observaron mejoras significativas en el salto ($t = -2.979$, $p = 0.021$, $d = -1.053$), flexiones ($p = 0.041$) y plancha ($p = 0.041$) después de la intervención. No se encontraron diferencias significativas entre hombres y mujeres ($p > 0.05$). Los resultados destacan la eficacia del programa para mejorar el rendimiento locomotor y la fuerza central en estudiantes con discapacidad intelectual.
Conclusión: El programa de ejercicio terapéutico de seis semanas demostró ser eficaz para mejorar las habilidades locomotoras, en particular el salto y la fuerza del tronco, en estudiantes con discapacidad intelectual. Se recomiendan actividades físicas simples y regulares para apoyar el desarrollo continuo y prevenir lesiones en esta población.

Palabras clave

Terapia de ejercicio; saltar la cuerda; salto; discapacidad intelectual.

Introduction

Modern approach to the pedagogy of intellectual disability has expanded to incorporate physical fitness as one of the bases of comprehensive development (Kavanagh et al., 2023; Mitsuhashi et al., 2023; Ruggiero-Ruff et al., 2023; Tepe et al., 2023; Yamaguchi et al., 2023). The study establishes the relationship that structured physical activity has toward the development of motor skills (Chen et al., 2023; Wang et al., 2022; Zheng et al., 2022). Activities that require balance, coordination, and agility, such as planking and jumping jacks, were the most effective activities in advancing locomotor proficiency. Enormous effort was put into the design and evaluation of exercise regimens, bearing in mind the uniqueness in needs of the intellectually disabled learners, since such interventions improved the overall health and functional ability of such people (Martinez de Lagran et al., 2022; Rais et al., 2022; Viglione et al., 2022; Waldron et al., 2022).

However, the issue of quick understanding the rapidity of students with intellectual disabilities to assimilate and replicate physical movements remained yet to be addressed. Scholars had yet to fully unravel how therapeutic fitness testing expedited the cognitive grasp of motor tasks. Sufficient attention has been given to the long-term benefits of physical activity of students who are intellectually disabled, but the immediate cognitive processing of exercise tasks has not been investigated very elaborately. However, the sophisticated interaction between cognitive promptness and motor skill execution called for a more detailed examination (Huang et al., 2022; Hura et al., 2022; Kwon et al., 2022; Malwade et al., 2022).

This was such a needed study to be conducted in this understudied area. The knowledge found has the potential for utterly reshaping instructional strategies within special education curricula (Hirano et al., 2022). A hypothesis that developed posited that regular and structured therapeutic fitness testing would not only sharpen physical abilities but also hasten cognitive alertness. Educators and therapists alike struggled with the challenge of being able to quantify quick understanding in an objective manner (Davis et al., 2022; Fenckova et al., 2022; Gao et al., 2022; Suthakaran et al., 2021). This was made more complex by individual variability in response to physical tasks, prompted by different intellectual abilities. Still more importantly, the development of exercise programs requiring careful individualization in light of an extraordinarily wide range of disabilities added to the problems in pedagogical methodologies (Mishra et al., 2021; Pitchford & Webster, 2021; Regaieg et al., 2021).

Regarding the physical benefits of exercise therapy, the majority of the reviewed work did not seem to investigate this subject further to capture the immediate cognitive response following therapeutic interventions. It is this void in research that the current study seeks to address, promising new and fruitful studies that can aid both educators and supporters of the intellectually disabled. This study sought to provide some solutions to this problem by examining the interaction between physical exercises and cognitive processing. It was intended to find out how quickly students were able to grasp and adapt to exercise routines. The rationale was that structured physical activity might double as an instrument for not only physical enhancement but also cognitive development.

The objectives of the research were multi-tiered: to assess the efficacy of therapeutic fitness testing in fostering rapid understanding and proficiency in locomotor skills, and to dissect the relationship between the cognitive speed of task acquisition and the performance of motor skills. This study was carried out to tackle these objectives and fill a large research void in the field of special education and therapeutic fitness. The significance of the study only went over and beyond mere academic interest; it had more far-reaching implications on science and society at large, being able to revolutionize methods of teaching and, by that, improve the life quality of learners with intellectual disabilities. Results of such analysis might then give rise to better educational practices and therapies to integrate these people more and better into society. Guided by these considerations, the central to the question around which the research pivotally revolved was how did participation in a therapeutic fitness testing program impact the acquisition of locomotor proficiency among students with intellectual disabilities?.

Method

Subjects and Ethical Considerations

The study involved eight students with intellectual disabilities enrolled in a specialized education program in Kendal, Central Java, Indonesia. Participants were selected through voluntary recruitment, and informed consent was obtained from their parents or legal guardians. While the voluntary nature of participation was ethically appropriate and ensured parental support, it may have introduced self-selection bias and limited the generalizability of the findings. Future studies are encouraged to apply probabilistic or stratified sampling techniques to enhance the external validity of the results. Moreover, the study did not classify participants based on the severity or level of intellectual disability (e.g., mild, moderate, or severe), which could have influenced individual responses to the intervention. Including this information in future research would allow for more nuanced analysis of intervention effects across different disability levels.

The study received ethical clearance from the Ethics Committee of STOK Bina Guna Medan, with approval number 076/LPPM-STOK-BG/Ecl/2024, and was conducted in accordance with the principles of the Declaration of Helsinki.

The Therapeutic Exercise Intervention

The therapeutic exercise in this study aims to improve the locomotor (jumping and skipping) of intellectual disability. The exercise was conducted for six weeks, three times a week, each 60 minutes. The main purpose of exercise program was to improve locomotor such as jumping and skipping, where this skill is very lacking in intellectual disability. We also considered about core strength and stability, abdominal strength, and upper body strength. The exercises under supervision of physical coach and physiotherapist.

Table 1. The therapeutic exercise program for six weeks

Week	Major Activity	Set	Repetition	Time (minutes)	Rest (minutes)
1	Plank	3	10	10	2
	Sit Up	3	10	10	2
	Push-Up	3	10	10	2
	Jumping	3	10	10	2
	Skipping	3	10	10	2
2	Plank	3	12	10	2
	Sit Up	3	12	10	2
	Push-Up	3	12	10	2
	Jumping	3	12	10	2
	Skipping	3	12	10	2
3	Plank	3	14	10	2
	Sit Up	3	14	10	2
	Push-Up	3	14	10	2
	Jumping	3	14	10	2
	Skipping	3	14	10	2
4	Plank	3	16	10	2
	Sit Up	3	16	10	2
	Push-Up	3	16	10	2
	Jumping	3	16	10	2
	Skipping	3	16	10	2
5	Plank	3	18	10	2
	Sit Up	3	18	10	2
	Push-Up	3	18	10	2
	Jumping	3	18	10	2
	Skipping	3	18	10	2
6	Plank	3	20	10	2
	Sit Up	3	20	10	2
	Push-Up	3	20	10	2
	Jumping	3	20	10	2
	Skipping	3	20	10	2

Note: the therapeutic exercise conducted on Monday, Wednesday and Friday, at 3-4 pm. Before the program have warming-up for 5 minutes and colling down for 5 minutes.

Research Equipment

The Equipment research used 1) stopwatch to control the time, 2) Cone used for distance in between subject during activity, 3) Matras used to help subject activity of plank, sit up, push up more convenient and safer.

Data Collection

The data was taken before and after six weeks therapeutic exercise. The plank, sit-up, push up, jumping, skipping data was taken by account it for a minute.

Statistical Analysis

The data was analyzed by descriptive data, distribution data. The hypothesis used paired t-test and t-test, with significance $p < 0.05$. The effect size was used Cohen's d.

Results

Results are presented and analyzed below:

Table 2. Descriptive data subject

Variable	Female n = 3		Male n = 5	
	Before (Mean ±SD)	After (Mean ±SD)	Before (Mean ±SD)	After (Mean ±SD)
Plank (second)	7.3 ± 6.4	20.0 ± 17.3	7.0 ± 9.7	12 ± 16.4
Sit-up (count in second)	2.3 ± 4.0	5.0 ± 8.6	5.2 ± 7.3	6.0 ± 8.2
Push-up (count in second)	1.3 ± 2.3	3.3 ± 5.7	3.6 ± 3.3	6.0 ± 5.7
Skipping (second)	11.7 ± 20.2	20.0 ±34.6	29.2 ± 26.7	36.0 ± 32.8
Jumping jack (second)	5.0 ± 4.0	10.0 ± 8.6	6.6 ±6.0	9.0 ± 8.2

Table 3. Independent Samples T-Test

	t	df	p	Mean Difference	SE Difference	95% CI for Mean Difference		Cohen's d	SE Cohen's d
						Lower	Upper		
Plank_Pre_(s)	0.052	6	0.960	0.333	6.413	-15.359	16.025	0.038	0.730
Plank_Post_(s)	0.655	6	0.537	8.000	12.220	-21.902	37.902	0.478	0.756
Sit Up_Pre_(s)	-0.616	6	0.560	-2.867	4.652	-14.250	8.516	-0.450	0.753
Sit Up_Post_(s)	-0.164	6	0.875	-1.000	6.110	-15.951	13.951	-0.120	0.732
Push Up_Pre_(s)	-1.017	6	0.348	-2.267	2.228	-7.719	3.186	-0.743	0.791
Push Up_Post_(s)	-0.655	6	0.537	-2.667	4.073	-12.634	7.301	-0.478	0.756
Skipping_Pre_(s)	-0.969	6	0.370	-17.533	18.095	-61.810	26.743	-0.708	0.785
Skipping_Post_(s)	-0.655	6	0.537	-16.000	24.440	-75.804	43.804	-0.478	0.756
Jumping Jack_Pre	-0.394	6	0.707	-1.600	4.057	-11.528	8.328	-0.288	0.740
Jumping_Jack_Post	0.164	6	0.875	1.000	6.110	-13.951	15.951	0.120	0.732

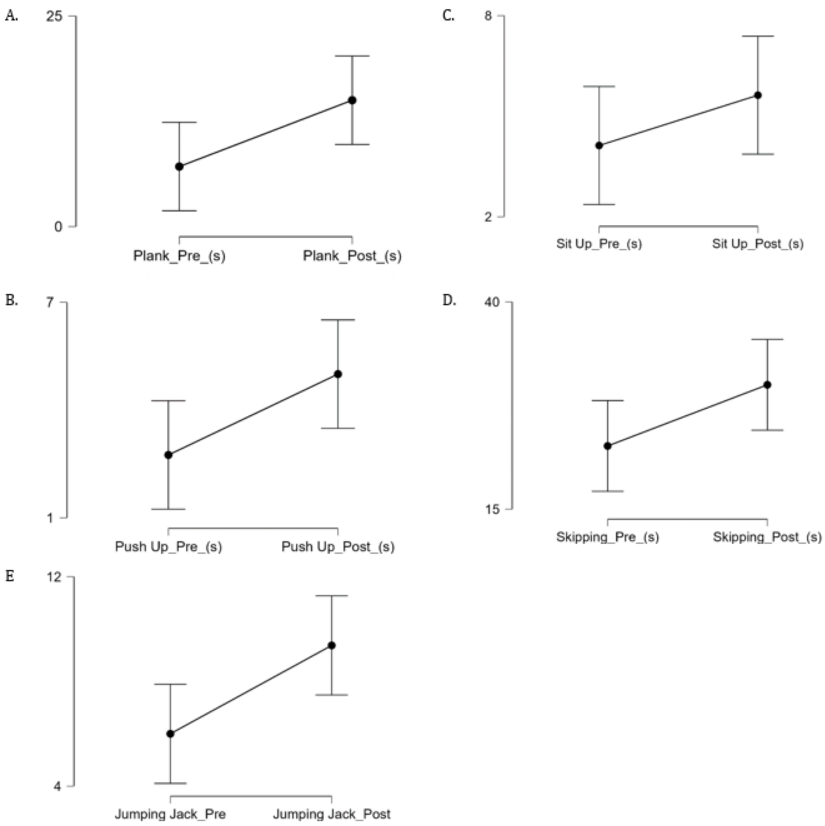
Note. Independent t-test ($p<0.05$)

Table 4. Paired Samples T-Test

Measure 1		Measure 2	t	df	p	Mean Difference	SE Difference	95% CI for Mean Difference		Cohen's d	SE Cohen's d
								Lower	Upper		
Plank_Pre_(s)	-	Plank_Post_(s)	-2.506	7	0.041	-7.875	3.142	-15.305	-0.445	-0.886	0.148
Sit Up_Pre_(s)	-	Sit Up_Post_(s)	-1.426	7	0.197	-1.500	1.052	-3.988	0.988	-0.504	0.134
Push Up_Pre_(s)	-	Push Up_Post_(s)	-2.496	7	0.041	-2.250	0.901	-4.381	-0.119	-0.883	0.116
Skipping_Pre_(s)	-	Skipping_Post_(s)	-2.253	7	0.059	-7.375	3.273	-15.114	0.364	-0.797	0.080
Jumping Jack_Pre	-	Jumping Jack_Post	-2.979	7	0.021	-3.375	1.133	-6.054	-0.696	-1.053	0.134

Note. Paired t-test, significant $p < 0.05$

Figure 1. The therapeutic exercise effect before and after program plank, sit up, push up, skipping and jumping jack.



Discussion

The result of the study reported that the six weeks of therapeutic exercise program significantly improved of plank ($p = 0.041$), push up ($p=0.041$) and jumping jack ($p = 0.021$). There is no different between gender of male and female ($p >0.05$). The differences depicted on the horizontal axis are all negative values, reflecting that all post-test scores were higher than pre-test scores. The central tendency of these differences was below zero, and the spread of data points demonstrated a general pattern of improvement across the participant group. These raincloud plots not only offer a visual representation of the descriptive statistics but also confirm the numerical data previously discussed. The downward shift in the scores indicates that subjects showed significant improvements in their locomotor skills as a result of the therapeutic fitness program. The extent and direction of these changes were in line with the research objectives, suggesting the program's effectiveness in enhancing the motor abilities of students with intellectual disabilities.

The investigation conducted offered compelling evidence for the integration of therapeutic fitness programs into the educational framework for intellectually disabled students. The increase in locomotor proficiency, as observed through the rise in post-test scores, resonated with prior research suggesting the profound benefits of physical activity in special education (O. W. K. Handayani et al., 2020; Mardiana et al., 2020; Muktiani et al., 2022; Pramono et al., 2023; Sumartiningsih et al., 2019). This augmentation of motor skills, statistically significant and practically relevant, demonstrated the effectiveness of exercise interventions tailored to this demographic (Hidayah et al., 2024; Lubis et al., 2021; Suganda et al., 2023).

The study contributed to the existing body of knowledge by quantifying the “quick understanding” phenomenon, defined as the immediate cognitive grasp of motor tasks following a structured fitness program. The sizeable effect sizes substantiated the exercises' role in the observed improvements and, hence, a contribution toward physical education for the intellectually disabled (O. W. K. Handayani et al., 2021; Lusiana, 2015, 2021; Purnama et al., 2021; Winara et al., 2021).

In this regard, it has further elaborated that the selected physical activities contributed very significantly toward the development of the locomotor skills among the students. This research thus filled a vital lacuna in the literature by providing empirical evidence of the cognitive benefits accompanying the physical improvements due to these interventions (Ani Hastuti et al., 2022; Azam et al., 2017; Hanief et al., 2021; Karbito et al., 2022; Nagahara et al., 2019).

Nonetheless, the study faced limitations, primarily the modest sample size, which, despite its adequacy for initial analysis, raised questions about the broader applicability of the findings. Future inquiries are encouraged to adopt a similar methodology across a variety of educational environments and with more subjects to further substantiate the reported outcomes.

Extending the discussion, the novel aspect of this research lay in its focus on immediate cognitive responses to physical exercise, an angle not extensively covered in earlier studies. The results underscored the duality of benefits – motoric and cognitive – emerging from exercise programs in special education curricula. This dual approach not only elevates the physical capacities of these students but also engages and enhances their cognitive abilities to comprehend and execute tasks promptly (Budiono et al., 2024; O. W. K. Handayani et al., 2019; Lusiana & Purnama, 2019; Mukarromah et al., 2021; Pramana et al., 2022; Raharjo et al., 2016).

The implications of this finding to science and society are profound. On the practices in education, the findings suggest a need for a revision in the design of curricular in such a way that it embeds physical activity as part of it (Lubis et al., 2022; Sumartiningsih, Rahayu, et al., 2022; Sumartiningsih, Risdiyanto, et al., 2022; Wajib et al., 2024). In scientific perspective, the study suggests many potential multidisciplinary treatments, while taking into consideration learning and development with specific regard to physical activity and cognitive processing (Ashadi et al., 2022; O. O. K. Handayani et al., 2019; Lusiana et al., 2021).

Referring to the problem statement and objectives of the study, the findings revealed mechanisms by which physical fitness might catalyze motor and cognitive development among students with intellectual disabilities (Alesi et al., 2018; Berg et al., 2020; Contesse et al., 2019; Fenckova et al., 2022; Klavina et al., 2017; Tepe et al., 2023). The findings have wider relevance and the potential for informing interventions that reach further than simply within the domain of ID to include a range of developmental and learning disorders (Iosa et al., 2014; Kitazawa et al., 2021; Kwon et al., 2022; Li et al., 2021; Martyn et al., 2018; Tang et al., 2017). The impact such programs could have on improving quality of life and increasing social involvement for people with disability is unquestionable (Abdulla et al., 2020; Brault et al., 2015; Lumsden et al., 2020; Pappas et al., 2017; Regaieg et al., 2021; Udobi et al., 2019).

Conclusions

The study concluded that a six-week therapeutic exercise program improves locomotor (jumping) of intellectual disability. There is no different effect between males and females before and after intervention. The study suggested improving physical activity, especially locomotor in intellectual disability, to prevent injury.

References

Abdulla, Z. I., Pahlevani, B., Lundgren, K. H., Pennington, J. L., Udobi, K. C., Seroogy, K. B., & Skelton, M. R. (2020). Deletion of the Creatine Transporter (Slc6a8) in Dopaminergic Neurons Leads to Hyperactivity in Mice. *Journal of Molecular Neuroscience*, *70*(1), 102–111. Scopus. https://doi.org/10.1007/s12031-019-01405-w

Alesi, M., Battaglia, G., Pepi, A., Bianco, A., & Palma, A. (2018). Gross motor proficiency and intellectual functioning A comparison among children with down syndrome, children with borderline intellectual functioning, and typically developing children. *Medicine (United States)*, *97*(41). Scopus. https://doi.org/10.1097/MD.0000000000012737

Ani Hastuti, T., Soegiyanto, Suherman, W. S., Rahayu, S., & Utami, N. S. (2022). Improving the pedagogic competence of physical education teachers. *Cakrawala Pendidikan*, *41*(2), 377–387. Scopus. https://doi.org/10.21831/cp.v41i2.48231

Berg, E. L., Ching, T. M., Bruun, D. A., Rivera, J. K., Careaga, M., Ellegood, J., Lerch, J. P., Wöhr, M., Lein, P. J., & Silverman, J. L. (2020). Translational outcomes relevant to neurodevelopmental disorders following early life exposure of rats to chlorpyrifos. *Journal of Neurodevelopmental Disorders*, *12*(1). Scopus. https://doi.org/10.1186/s11689-020-09342-1

Brault, V., Duchon, A., Romestaing, C., Sahun, I., Pothion, S., Karout, M., Borel, C., Dembele, D., Bizot, J.-C., Messaddeq, N., Sharp, A. J., Roussel, D., Antonarakis, S. E., Dierssen, M., & Hérault, Y. (2015). Opposite Phenotypes of Muscle Strength and Locomotor Function in Mouse Models of Partial Trisomy and Monosomy 21 for the Proximal Hspa13-App Region. *PLoS Genetics*, *11*(3). Scopus. https://doi.org/10.1371/journal.pgen.1005062

Chen, J., Salveridou, E., Liebmann, L., Sundaram, S. M., Doycheva, D., Markova, B., Hübner, C. A., Boelen, A., Visser, W. E., Heuer, H., & Mayerl, S. (2023). Triac Treatment Prevents Neurodevelopmental and Locomotor Impairments in Thyroid Hormone Transporter Mct8/Oatp1c1 Deficient Mice. *International Journal of Molecular Sciences*, *24*(4). Scopus. https://doi.org/10.3390/ijms24043452

Contesse, T., Ayrault, M., Mantegazza, M., Studer, M., & Deschaux, O. (2019). Hyperactive and anxiolytic-like behaviors result from loss of COUP-TFI/Nr2f1 in the mouse cortex. *Genes, Brain and Behavior*, *18*(7). Scopus. https://doi.org/10.1111/gbb.12556

Davis, L., Rayi, P. R., Getselter, D., Kaphzan, H., & Elliott, E. (2022). CTCF in parvalbumin-expressing neurons regulates motor, anxiety and social behavior and neuronal identity. *Molecular Brain*, *15*(1). Scopus. https://doi.org/10.1186/s13041-022-00916-9

Fenckova, M., Muha, V., Mariappa, D., Catinozzi, M., Czajewski, I., Blok, L. E. R., Ferenbach, A. T., Storkebaum, E., Schenck, A., & van Aalten, D. M. F. (2022). Intellectual disability-associated disruption of O-GlcNAc cycling impairs habituation learning in Drosophila. *PLoS Genetics*, *18*(5). Scopus. https://doi.org/10.1371/journal.pgen.1010159

Gao, Y., Aljazi, M. B., & He, J. (2022). Neural Hyperactivity Is a Core Pathophysiological Change Induced by Deletion of a High Autism Risk Gene Ash1L in the Mouse Brain. *Frontiers in Behavioral Neuroscience*, *16*. Scopus. https://doi.org/10.3389/fnbeh.2022.873466

Handayani, O. O. K., Wiranti, I., Raharjo, B. B., & Nugroho, E. (2019). The reproduction health behavior of high school teenagers in semarang, indonesia. *Open Public Health Journal*, *12*(1), 309–314. Scopus. https://doi.org/10.2174/1874944501912010309

Handayani, O. W. K., Nugroho, E., & Hermawati, B. (2020). Determinant of diabetes mellitus focusing on differences of Indonesian culture: Case studies in the Java and outer java region in Indonesia. *Open Public Health Journal*, *13*(1), 323–330. Scopus. https://doi.org/10.2174/1874944502013010323

Handayani, O. W. K., Yuniastuti, A., Abudu, K. O., & Nugroho, E. (2021). Gadget Addiction and The Effect of Sleep Habit, Stress, Physical Activity to Obesity. *Malaysian Journal of Public Health Medicine*, *21*(1), 1–8. Scopus. https://doi.org/10.37268/MJPHM/VOL.21/NO.1/ART.272

Hanief, Y. N., Widiawati, P., Supriatna, Abdullah, A., & Sumartiningsih, S. (2021). Injury characteristics of indonesian paraathletes prior to tokyo olympics 2020: A cross-sectional study. *Revista Pesquisa Em Fisioterapia*, *11*(4), 679–690. Scopus. https://doi.org/10.17267/2238-2704rpf.v11i4.4065

Hirano, D., Goto, Y., Shoji, H., & Taniguchi, T. (2022). Comparison of the presence and absence of an intervention to reduce hand stereotypies in individuals with Rett syndrome. *Journal of Applied Research in Intellectual Disabilities*, *35*(2), 607–622. Scopus. https://doi.org/10.1111/jar.12973

Huang, Y., Lemire, G., Briere, L. C., Liu, F., Wessels, M. W., Wang, X., Osmond, M., Kanca, O., Lu, S., High, F. A., Walker, M. A., Rodan, L. H., Kernohan, K. D., Sweetser, D. A., Boycott, K. M., & Bellen, H. J. (2022). The recurrent de novo c.2011C>T missense variant in MTSS2 causes syndromic intellectual disability. *American Journal of Human Genetics*, *109*(10), 1923–1931. Scopus. https://doi.org/10.1016/j.ajhg.2022.08.011

Hura, A. J., Hawley, H. R., Tan, W. J., Penny, R. J., Jacobsen, J. C., & Fitzsimons, H. L. (2022). Loss of Drosophila Coq8 results in impaired survival, locomotor deficits and photoreceptor degeneration. *Molecular Brain*, *15*(1). Scopus. https://doi.org/10.1186/s13041-022-00900-3

Iosa, M., Morelli, D., Nisi, E., Sorbara, C., Negrini, S., Gentili, P., Paolucci, S., & Fusco, A. (2014). Assessment of upper body accelerations in young adults with intellectual disabilities while walking, running, and dual-task running. *Human Movement Science*, *34*(1), 187–195. Scopus. https://doi.org/10.1016/j.humov.2014.02.005

Kavanagh, H., Manninen, M., & Issartel, J. (2023). Comparing the fundamental movement skill proficiency of children with intellectual disabilities and typically developing children: A systematic review and meta-analysis. *Journal of Intellectual Disability Research*, *67*(12), 1336–1353. Scopus. https://doi.org/10.1111/jir.13012

Kitazawa, M., Sutani, A., Kaneko-Ishino, T., & Ishino, F. (2021). The role of eutherian-specific RTL1 in the nervous system and its implications for the Kagami-Ogata and Temple syndromes. *Genes to Cells*, *26*(3), 165–179. Scopus. https://doi.org/10.1111/gtc.12830

Klavina, A., Ostrovska, K., & Campa, M. (2017). Fundamental movement skill and physical fitness measures in children with disabilities. *European Journal of Adapted Physical Activity*, *10*(1), 28–37. Scopus. https://doi.org/10.5507/euj.2017.004

Kwon, H., Maeng, H., & Chung, J. (2022). Development of an ICT-Based Exergame Program for Children with Developmental Disabilities. *Journal of Clinical Medicine*, *11*(19). Scopus. https://doi.org/10.3390/jcm11195890

Li, D., Wang, Q., Gong, N. N., Kurolap, A., Feldman, H. B., Boy, N., Brugger, M., Grand, K., McWalter, K., Guillen Sacoto, M. J., Wakeling, E., Hurst, J., March, M. E., Bhoj, E. J., Nowaczyk, M. J. M., Gonzaga-Jauregui, C., Mathew, M., Dava-Wala, A., Siemon, A., … Hakonarson, H. (2021). Pathogenic variants in SMARCA5, a chromatin remodeler, cause a range of syndromic neurodevelopmental features. *Science Advances*, *7*(20). Scopus. https://doi.org/10.1126/sciadv.abf2066

Lubis, J., Fitrianto, E. J., Sukiri, Haqiyah, A., Setiakarnawijaya, Y., Robianto, A., Sukriadi, S., Nurulfa, R., Irawan, A. A., & Sumartiningsih, S. (2021). Does aerobic interval training induce a decrease in body weight in pencak silat elite athletes? *Journal of Physical Education and Sport*, *21*, 2372–2380. Scopus. https://doi.org/10.7752/jpes.2021.s4318

Lubis, J., Thongdaeng, N., Haqiyah, A., Sukur, A., Abidin, D., Irawan, A. A., Sumartiningsih, S., & Hanief, Y. N. (2022). The Effect of Five-Week Aerobic Interval Training on the Body Composition of Pencak Silat Elite Athletes. *International Journal of Kinesiology and Sports Science*, *10*(2), 16–24. Scopus. https://doi.org/10.7575/aiac.ijkss.v.10n.2p.16

Lumsden, E. W., McCowan, L., Pescrille, J. D., Fawcett, W. P., Chen, H., Albuquerque, E. X., Mamczarz, J., & Pereira, E. F. R. (2020). Learning and memory retention deficits in prepubertal guinea pigs prenatally exposed to low levels of the organophosphorus insecticide malathion. *Neurotoxicology and Teratology*, *81*. Scopus. https://doi.org/10.1016/j.ntt.2020.106914

Lusiana, L. (2015). Factors Influencing Shooting Ability in Female Handball Athletes of Central Java. *Journal of Physical Education Health and Sport*, *2*(2), 65–68. https://journal.unnes.ac.id/nju/jpehs/article/view/4589

Lusiana, L. (2021). Evaluation of Gymnastics Training and Development in Central Java. *JOURNAL OF EDUCATION AND SPORT SCIENCE*, *1*(1). https://publikasiilmiah.unwahas.ac.id/index.php/JESS/article/view/4295

Lusiana, L., & Purnama, Y. (2019). Soft Skills Abilities of Physical Education Teachers in the Working Group of Mts Jepara in the Year 2019. *Journal Of Sport Education (JOPE)*, *2*(1), 1–9. https://jope.ejournal.unri.ac.id/index.php/jope/article/view/7872

Lusiana, L., Purnama, Y., Arie, Y., & Wicaksono, G. H. (2021). The Influence of Bhineka Tunggal Ika Gymnastics on Resting Pulse Rate. *Journal of Sport Coaching and Physical Education*, *6*(1), 20–27. https://journal.unnes.ac.id/sju/jscpe/article/view/46032

Malwade, S., Gasthaus, J., Bellardita, C., Andelic, M., Moric, B., Korshunova, I., Kiehn, O., Vasistha, N. A., & Khodosevich, K. (2022). Identification of Vulnerable Interneuron Subtypes in 15q13.3 Microdeletion Syndrome Using Single-Cell Transcriptomics. *Biological Psychiatry*, *91*(8), 727–739. Scopus. https://doi.org/10.1016/j.biopsych.2021.09.012

Mardiana, Budiono, I., & Putriningtyas, N. D. (2020). Comparison of organoleptic, protein, lipid and flavonoid content of commercial starter and isolated culture red dragon fruit peel yogurt. *Food Research*, *4*(3), 920–925. Scopus. https://doi.org/10.26656/fr.2017.4(3).380

Martinez de Lagran, M., Elizalde-Torrent, A., Paredes, R., Clotet, B., & Dierssen, M. (2022). Lamivudine, a reverse transcriptase inhibitor, rescues cognitive deficits in a mouse model of down syndrome. *Journal of Cellular and Molecular Medicine*, *26*(15), 4210–4215. Scopus. https://doi.org/10.1111/jcmm.17411

Martyn, A. C., Toth, K., Schmalzigaug, R., Hedrick, N. G., Rodriguiz, R. M., Yasuda, R., Wetsel, W. C., & Premont, R. T. (2018). GIT1 regulates synaptic structural plasticity underlying learning. *PLoS ONE*, *13*(3). Scopus. https://doi.org/10.1371/journal.pone.0194350

Mishra, R. S., Mohanty, S. K., Cordes, J., Sahoo, U., Singh, R. R., & Subramanian, S. V. (2021). Economic gradient of onset of disability in India. *BMC Public Health*, *21*(1). Scopus. https://doi.org/10.1186/s12889-021-10826-5

Mitsuhashi, T., Hattori, S., Fujimura, K., Shibata, S., Miyakawa, T., & Takahashi, T. (2023). In utero Exposure to Valproic Acid throughout Pregnancy Causes Phenotypes of Autism in Offspring Mice. *Developmental Neuroscience*, *45*(5), 223–233. Scopus. https://doi.org/10.1159/000530452

Mukarromah, S. B., Hidayah, T., Sumartiningsih, S., Ali, M. A., Hakim, A. A., Lesmana, R., & Giang, N. T. (2021). Serum dehydroepiandrosterone (Dhea) concentration after aquarobic training in premenopausal women with obesity. *Journal of Physical Education and Sport*, *21*, 2402–2407. Scopus. https://doi.org/10.7752/jpes.2021.s4322

Nagahara, R., Amini, E., Marcon, K. C. C., Chen, P.-W., Chua, J., Eiberger, J., Futalan, N. J. C., Lye, J., Pantovic, M. M., Starczewski, M., Sudsa-Ard, K., Sumartiningsih, S., Wang, C.-Y., William, T. B., Kasujja, T., & Gujar, T. A. (2019). Influence of the intention to lean the body forward on kinematics and kinetics of sprinting for active adults. *Sports*, *7*(6). Scopus. https://doi.org/10.3390/sports7060133

Pappas, A. L., Bey, A. L., Wang, X., Rossi, M., Kim, Y. H., Yan, H., Porkka, F., Duffney, L. J., Phillips, S. M., Cao, X., Ding, J.-D., Rodriguiz, R. M., Yin, H. H., Weinberg, R. J., Ji, R.-R., Wetsel, W. C., & Jiang, Y.-H. (2017). Deficiency of Shank2 causes mania-like behavior that responds to mood stabilizers. *JCI Insight*, *2*(20). Scopus. https://doi.org/10.1172/jci.insight.92052

Pitchford, E. A., & Webster, E. K. (2021). Clinical validity of the test of gross motor development-3 in children with disabilities from the U.S. national normative sample. *Adapted Physical Activity Quarterly*, *38*(1), 62–78. Scopus. https://doi.org/10.1123/APAQ.2020-0023

Pramana, C., Handayani, O. W. K., Raharjo, T. J., & Rahayu, S. R. (2022). Nursing Students' Perceptions and Acceptance of Online Learning during the COVID-19 Pandemic in Indonesia. *Open Access Macedonian Journal of Medical Sciences*, *10*(G), 183–188. Scopus. https://doi.org/10.3889/oamjms.2022.8329

Pramono, B. A., Mustar, Y. S., Sumartiningsih, S., Marsudi, I., Hariyanto, A., Sidik, M. A., & Kusuma, I. D. M. A. W. (2023). ANALYSIS OF REACTION TIME, SPLIT TIME AND FINAL TIME SWIMMING ATHLETES IN THE OLYMPIC GAMES ON 2008-2021. *Physical Education Theory and Methodology*, *23*(3), 346–352. Scopus. https://doi.org/10.17309/tmfv.2023.3.05

Rais, M., Lovelace, J. W., Shuai, X. S., Woodard, W., Bishay, S., Estrada, L., Sharma, A. R., Nguy, A., Kulinich, A., Pirbhoy, P. S., Palacios, A. R., Nelson, D. L., Razak, K. A., & Ethell, I. M. (2022). Functional consequences of postnatal interventions in a mouse model of Fragile X syndrome. *Neurobiology of Disease*, *162*. Scopus. https://doi.org/10.1016/j.nbd.2021.105577

Regaieg, G., Sahli, S., & Kermarrec, G. (2021). Hybrid program based on virtual and real games increases fundamental movement skills in children with intellectual disability: A quasi-experimental study. *Adapted Physical Activity Quarterly*, *38*(4), 626–642. Scopus. https://doi.org/10.1123/APAQ.2020-0180

Ruggiero-Ruff, R. E., Villa, P. A., Hijleh, S. A., Avalos, B., DiPatrizio, N. V., Haga-Yamanaka, S., & Coss, D. (2023). Increased body weight in mice with fragile X messenger ribonucleoprotein 1 (Fmr1) gene mutation is associated with hypothalamic dysfunction. *Scientific Reports*, *13*(1). Scopus. https://doi.org/10.1038/s41598-023-39643-z

Sumartiningsih, S., Risdiyanto, A., Yusof, A., Rahayu, S., Handoyo, E., Puspita, M. A., Sugiharto, Mukarromah, S. B., Hooi, L. B., Lubis, J., Hanief, Y. N., Festiawan, R., & Eiberger, J. (2022). The FIFA 11+ for kids warm-up program improved balance and leg muscle strength in children (9–12 years old). *Journal of Physical Education and Sport*, *22*(12), 3122–3127. Scopus. https://doi.org/10.7752/jpes.2022.12395

Suthakaran, N., Wiggins, J., Giles, A., Opperman, K. J., Grill, B., & Dawson-Scully, K. (2021). O-GlcNAc transferase OGT-1 and the ubiquitin ligase EEL-1 modulate seizure susceptibility in C. elegans. *PLoS ONE*, *16*(11 November). Scopus. https://doi.org/10.1371/journal.pone.0260072

Tang, S., Wang, I.-T. J., Yue, C., Takano, H., Terzic, B., Pance, K., Lee, J. Y., Cui, Y., Coulter, D. A., & Zhou, Z. (2017). Loss of CDKL5 in glutamatergic neurons disrupts hippocampal microcircuitry and leads to memory impairment in mice. *Journal of Neuroscience*, *37*(31), 7420–7437. Scopus. https://doi.org/10.1523/JNEUROSCI.0539-17.2017

Tepe, B., Macke, E. L., Niceta, M., Weisz Hubshman, M., Kanca, O., Schultz-Rogers, L., Zarate, Y. A., Schaefer, G. B., Granadillo De Luque, J. L., Wegner, D. J., Cogne, B., Gilbert-Dussardier, B., Le Guillou, X., Wagner, E. J., Pais, L. S., Neil, J. E., Mochida, G. H., Walsh, C. A., Magal, N., … Klee, E. W. (2023). Bi-allelic variants in INTS11 are associated with a complex neurological disorder. *American Journal of Human Genetics*, *110*(5), 774–789. Scopus. https://doi.org/10.1016/j.ajhg.2023.03.012

Udobi, K. C., Delcimmuto, N., Kokenge, A. N., Abdulla, Z. I., Perna, M. K., & Skelton, M. R. (2019). Deletion of the creatine transporter gene in neonatal, but not adult, mice leads to cognitive deficits. *Journal of Inherited Metabolic Disease*, *42*(5), 966–974. Scopus. https://doi.org/10.1002/jimd.12137

Viglione, A., Sagona, G., Carrara, F., Amato, G., Totaro, V., Lupori, L., Putignano, E., Pizzorusso, T., & Mazziotti, R. (2022). Behavioral impulsivity is associated with pupillary alterations and hyperactivity in CDKL5 mutant mice. *Human Molecular Genetics*, *31*(23), 4107–4120. Scopus. https://doi.org/10.1093/hmg/ddac164

Wajib, M., Rahayu, S., Winarno, M. E., & Sumartiningsih, S. (2024). The correlation of endurance and speed on the performance of Long-Distance Runners 2022 in East Java Province. *International Journal of Disabilities Sports and Health Sciences*, *7*(2), 437–444. Scopus. https://doi.org/10.33438/ijdshs.1367949

Waldron, S., Pass, R., Griesius, S., Mellor, J. R., Robinson, E. S. J., Thomas, K. L., Wilkinson, L. S., Humby, T., Hall, J., & Dwyer, D. M. (2022). Behavioural and molecular characterisation of the Dlg2 haploinsufficiency rat model of genetic risk for psychiatric disorder. *Genes, Brain and Behavior*, *21*(4). Scopus. https://doi.org/10.1111/gbb.12797

Wang, T., Qian, Y., Zhong, T., & Qi, J. (2022). Associations between Fundamental Movement Skills and Moderate-to-Vigorous Intensity Physical Activity among Chinese Children and Adolescents with Intellectual Disability. *International Journal of Environmental Research and Public Health*, *19*(20). Scopus. https://doi.org/10.3390/ijerph192013057

Winara, Handayani, O. W. K., Sulaiman, & Rumini. (2021). Effect of tempe drinks on muscle recovery (Malondialdehyde) and sub-maximum activity on sparta DK Percut Sei Tuan football players in Deli Serdang Regency, North Sumatra Province. *International Journal of Human Movement and Sports Sciences*, *9*(1), 130–134. Scopus. https://doi.org/10.13189/saj.2021.090118

Yamaguchi, M., Huynh, M. A., Chiyonobu, T., & Yoshida, H. (2023). Knockdown of Chronophage in the nervous system mimics features of neurodevelopmental disorders caused by BCL11A/B variants. *Experimental Cell Research*, *433*(2). Scopus. https://doi.org/10.1016/j.yexcr.2023.113827

Zheng, J., Long, F., Cao, X., Xiong, B., & Li, Y. (2022). Knockout of Katnal2 Leads to Autism-like Behaviors and Developmental Delay in Zebrafish. *International Journal of Molecular Sciences*, *23*(15). Scopus. https://doi.org/10.3390/ijms23158389

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