The Relationship between Anthropometric, Biomotor, and Psychomotor Factors on the Performance of Paralympic 100 Meters Freestyle Swimming Athletes in National Paralympic Committee Indonesia
La relación entre los factores antropométricos, biomotores y psicomotores en el rendimiento de los atletas paralímpicos de natación estilo libre de 100 metros en el Comité Paralímpico Nacional de Indonesia

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Abstract. This research aims to relationship the anthropometric, biomotor, and psychomotor factors with disabled athlete's swimming speed in the National Paralympic Committee (NPC) (Indonesian) 100-meter freestyle competition in 2022. This research was a cross-sectional study conducted by the National Paralympic Committee (NPC) (Indonesia). The sample used in this research was 15 disabled athletes from NPC Indonesia with the S7-S10 classification who got medals at the ASEAN Para Games event in 2022. The data collection includes seven independent variable tests there are anthropometric factors (height, weight, body mass index, arm length, and leg length); biomotor factors (abdominal muscle strength and arm muscle power); psychomotor factors by measuring balance using Balance Tests; and dependent variables by measuring swimming speed using the 100-meter freestyle swimming ability test. Statistical analysis used the Pearson correlation coefficient test with a significance level of 5%. The results of the Pearson correlation coefficient analysis show that swimming speed was negatively related to body height, body weight, arm length, abdominal muscle strength, and arm muscle power indicating a moderate correlation between variables ($p \leq 0.001$). However, unfortunately, other anthropometric variables such as leg length and age showed a weak negative correlation with swimming speed ($p \leq 0.05$). Meanwhile, body mass index and balance did not show a significant correlation with swimming speed ($p \geq 0.05$). Based on the research results, it was concluded that anthropometric and biomotor factors showed a negative relationship with swimming speed, while psychomotor factors did not.
Keyword: Anthropometry, biomotor, psychomotor, disabled athletes, swimming speed, achievement.

Resumen. Esta investigación tiene como objetivo relacionar los factores antropométricos, biomotores y psicomotores con la velocidad de natación de atletas discapacitados en la competencia de estilo libre de 100 metros del Comité Paralímpico Nacional (NPC) (Indonesia) en 2022. Esta investigación fue un estudio transversal realizado por el Comité Paralímpico Nacional Comité (NPC) (Indonesia). La muestra utilizada en esta investigación fue de 15 atletas discapacitados del NPC Indonesia con la clasificación S7-S10 que obtuvieron medallas en el evento Para Juegos de la ASEAN en 2022. La recolección de datos incluye siete pruebas de variables independientes, existen factores antropométricos (altura, peso, masa corporal). índice, longitud del brazo y longitud de la pierna); factores biomotores (fuerza de los músculos abdominales y potencia de los músculos del brazo); factores psicomotores midiendo el equilibrio mediante Balance Tests; y variables dependientes midiendo la velocidad de natación mediante la prueba de capacidad de natación estilo libre de 100 metros. El análisis estadístico utilizó la prueba del coeficiente de correlación de Pearson con un nivel de significancia del 5%. Los resultados del análisis del coeficiente de correlación de Pearson muestran que la velocidad de nado se relacionó negativamente con la altura corporal, el peso corporal, la longitud del brazo, la fuerza de los músculos abdominales y la potencia de los músculos del brazo, indicando una correlación moderada entre las variables ($p \leq 0,001$). Sin embargo, desafortunadamente, otras variables antropométricas como la longitud de las piernas y la edad mostraron una correlación negativa débil con la velocidad de nado ($p \leq 0,05$). Mientras tanto, el índice de masa corporal y el equilibrio no mostraron correlación significativa con la velocidad de nado ($p \geq 0,05$). Con base en los resultados de la investigación, se concluyó que los factores antropométricos y biomotores mostraron una relación negativa con la velocidad de nado, mientras que los factores psicomotores no.
Palabra clave: Antropometría, biomotora, psicomotora, deportistas discapacitados, velocidad de nado, logro.

Introduction

Swimming is a form of movement in water in which the body moves forward by periodically using the upper and lower limbs to promote forward motion (Morais et al., 2022). Swimming done regularly can improve joint flexibility, body coordination, and muscle growth (Sellés-Pérez et al., 2023; Kauki et al., 2024). Swimming is an exercise that works every muscle in the body, particularly the muscles of the spine, and can be beneficial for body deformities like rickets and the curvature of the back and leg (Fernandes et al., 2023). Swimming is categorized as a water-based activity encompassing games and competitions (Powell et al., 2023).

Swimming competition stands out as one of the widely embraced olympic sports, featuring diverse events spanning different distances in butterfly, backstroke, breaststroke, individual medley, and crawl/free style (Gonjo et al., 2021). Free style is one of the most common styles in the race because the movements performed are very easy and simple (Verrelli et al., 2023). Free style swimming can be done quickly according to the swimmer's physical strength (Born et al., 2020). In any sports, athletes play a leading role in every race. Not all athletes have a perfect body morphology. But that doesn't stop them from achieving a victory (Canpolat & Akyol, 2023). There are many sports that have begun to give disabled athletes the opportunity to develop their potential (Engdahl-Høgåsen & Bentzen, 2023). There are distinct physical and physiological requirements for the majority of team and individual sports, some of which are more prominent than others (Lui & Lui, 2023). Paralympics, or the sport for athletes with

disabilities, need to keep developing in tandem with mainstream athlete sports (Ersöz & Esen, 2023). Researchers and coaches are still looking for the best ways to train athletes for paralympic sports (Alkhawaldeh & Alzughilat, 2023). Paralympic swimming is one of the Olympic sports overseen by the International Paralympic Committee (IPC) and including a sizable athlete field (Puce et al., 2018). The factors that determine the success of the race are intrinsic and extrinsic (González Palacio et al., 2022). These factors include: technical, tactical, mental, anthropometric, biomotor, psychomotor, motivation, nutrition, genetics, and so on (Post et al., 2023). Anthropometric, biomotor, and psychomotor factor analysis for disabled athletes is very useful for the trainer to develop a qualified training program to support the performance of the disabled (Jiménez-Alfageme et al., 2022). Considering that varying anthropometric requirements would result in variations in physiological and physical characteristics amongst disabilities (Cherif et al., 2022). As a result, anthropometric standards are frequently used to identify athletic talent, particularly in swimming (Bond et al., 2015). Anthropometric factors and other variables have been shown in a body of literature to be potential predictors of swimming performance (Bond et al., 2015). Anthropometric characteristics and swimming performance are closely related in sports (Lima-Borges et al., 2022). Biomotor is the biological factor that affects a person's physical performance (Delas et al., 2007). Biomotors in swimming have the main components, among others, speed, strength, endurance, flexibility, and coordination (Ben-Zaken et al., 2022). Psychomotor related to physical activity that can be controlled by the body to carry out physical responses easily with controllable body response behavior (Cratty & Noble, 2022). Open sports require a high level of psychomotor skills, which can make the difference between an athlete's and a team's performance (Śliż et al., 2022). Athletes with disabilities have unique potential and talent, and sports provide opportunities to develop these potentials. There is an increasing participation of disabled athletes in various sports disciplines, including the Paralympic Games. Indonesia has achieved remarkable s in the ASEAN Para Games successful won a total of 87 medals consisting of 29 golds, 31 silvers and 27 bronzes. This success may serve as a catalyst to further understand the factors contributing to the outstanding performance of Indonesian disabled athletes in swimming. The issue that inspires this research is that there have been many disabled athletes participating in competitions, but there is still very little research that discusses factors that can improve the performance of disabled athletes, especially in swimming. Based on this background, researchers are interested in conducting this research aims to relationship the anthropometric, biomotor, and psychomotor factors with disabled athlete's swimming speed in the National Paralympic Committee (NPC) (Indonesian) 100-meter freestyle competition in 2022.

Material and Methods

Study design

This research was a cross-sectional study conducted in National Paralympic Committee (NPC) (Indonesia). The population in this research consisted of 47 Indonesian National Paralympic Committee (NPC) swimming athletes who competed in the 2022 Asean Para Games Championship in Indonesia. However, the sample used in this research was 15 disabled athletes from NPC Indonesia with the S7-S10 classification which got medals at the ASEAN Para Games event in 2022. Informed consent was obtained after the subject received clear and detailed information regarding the research procedures. The procedures applied in this study were carried out in accordance with the Declaration of Helsinki and approved by the Health Research Ethics Committee, Faculty of Medicine, University of Brawijaya (ethics number: 260/EC/KEPK/09/2021).

Data collection

This research was carried out in March 2022 and took place at the Kusuma Sahid Hotel Swimming Pool, Indapatri Karanganyar Swimming Pool, and Hotel Lorin Solo. These three places are training grounds and accommodation for Indonesian PARA Swimming athletes. The data collection method used in this study was test and measurement. Data variation includes independent and dependent variables tests carried out within two days. The data collection includes seven independent variable tests there are anthropometric factors (height, weight, body mass index, arm length, and leg length). Height was measured using a portable stadiometer seca 213 (Pranoto et al., 2023), weight was measured using a digital scale OMRON Model HN-289, body mass index was calculated by dividing the weight (kg) divided by the height (m^2) (Raharjo et al., 2021), arm length and leg length was measured using a Tape Pita SECA 201 (Montejano Lozoya et al., 2017). Biomotor factors (abdominal muscle strength using Sit Up Test 60 second and arm muscle power using Medicine ball throw tests). Psychomotor factors by measuring balance using Balance Tests. Dependent variables by measuring swimming speed using the 100-meter freestyle swimming ability test.

Statistic analysis

The data analysis of this research used descriptive tests in the form of mean, standard deviation, and percentage to describe the classification of disabled swimmers. The normality test used the Shapiro–Wilk test, while the correlation test used the Pearson correlation coefficient test. All statistical analyses used a significant level of 5%.

Results

The results of the study were obtained from measurements of seven independent variables, namely:

anthropometric factors consisting of height, weight, arm length, and leg length; biomotor factors (abdominal muscle strength and arm muscle power); psychomotor factors (balance); and one dependent variable, namely the swimming test ability of 100 metres freestyle (swimming speed). The data obtained from each variable is then grouped and analysed using statistical techniques shown in Table 1.

The results of the Pearson correlation coefficient analysis show that swimming speed was negatively related to body height (r = −0.814, p = 0.000), body weight (r = −0.696, p = 0.004), arm length (r = −0.790, p = 0.000), abdominal muscle strength (r = −0.956, p = 0.000), and arm muscle power (r = −0.690, p = 0.004) indicating a moderate correlation between variables. However, unfortunately other anthropometric variables such as leg length (r = −0.611, p = 0.016), and age (r = − 0.576, p = 0.025) showed a weak negative correlation with swimming speed. Meanwhile, body mass index and balance did not show a significant correlation with swimming speed (r = − 0.041, p ≥ 0.05) and (r = −0.363, p ≥ 0.05) (Figure 1).
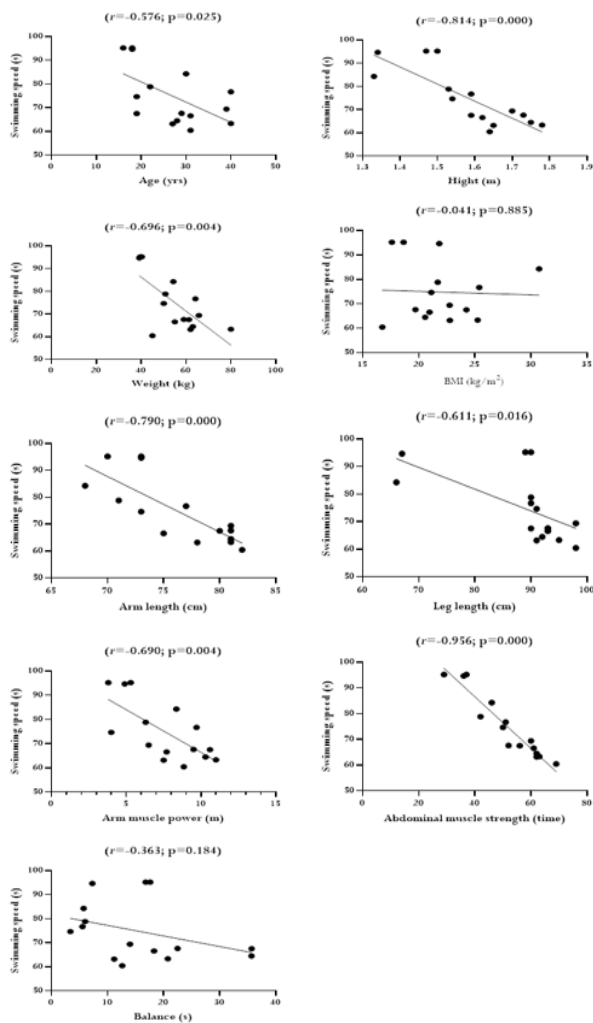

Figure 1. The Relationship between Anthropometric, Biomotor, and Psychomotor Factors with swimming speed. Description: Pearson correlation coefficients (r) and p-values are shown in each graph.

Table 1.
Characteristics of study subjects

Variables		n	Mean ± SD	Percentage (%)
Classification of disabled swimmers:				
1.	S7	2		13.33
2.	S8	3		20.00
3.	S9	6		40.00
4.	S10	4		26.67
Total		15		100.00
Age (yrs)		15	27.13±8.29	-
Height (m)		15	1.58±0.14	-
Weight (kg)		15	55.31±11.45	-
Body mass index (kg/m^2)		15	22.01±3.51	-
Arm length (cm)		15	76.27±4.69	-
Leg length (cm)		15	88.87±9.50	-
Arm muscle power (m)		15	7.62±2.41	-
Abdominal muscle strength (time)		15	51.73±11.71	-
Balance (s)		15	15.54±10.12	-
Swimming speed (s)		15	74.83±12.29	-

Discussion

The results showed that anthropometric and biomotor factors influenced the 100-meter freestyle swimming performance in athletes with disabilities, while psychomotor factors did not influence swimming speed (Figure 1). The results of the research obtained related to the most dominant anthropometric factor in the ability to swim 100 meters freely are height, based on the previous study conducted by (Moura et al., 2014) showing results that swimming speed was significantly positively correlated with body height (p = 0.013). Another study conducted by (Cherif et al., 2022) describes that the 50-meter freestyle swimming performance was significantly related to the athlete's height and weight. And then (Lätt et al., 2010) describe that the results of a partial correlation analysis indicated a significant correlation between swimming performance and body height. A more recent study by (Zampagni et al., 2008) examined the impact of body height on several swimming events utilizing 50, 100, 200, 400, and 800 m free competitions by 135 professional master swimmers. According to the results, one of the top three factors for the short-distance races was body height. The observation that taller swimmers appear to glide through the water more smoothly may help to explain the consistent correlation between height and swimming speed.

The result of the biomotor factor that dominates the ability to swim 100 meters freestyle in this study is the power of the arm muscles. The results of the study are in line with previous research carried out by (Falaahudin et al., 2021) there's a strong correlation between the power of the arms and the efficiency of a 25-meter crawl swimming with a correlation. Arm power is needed to pull water when the hand moves from the front to the bottom of the abdomen. The larger a person's arm power, the greater the attraction generated, so the speed of the forward swim is also faster. In swimming, arm power, leg power, and muscle strength all work together to produce forward motion (Putra & Witarsyah, 2019). The ability to generate maximal swimming speed in the freestyle technique is dependent on several parameters, including height, strength of the legs,

and arm power. The swimmer's arm and leg muscles influence how quickly they can swim in freestyle, particularly when covering a distance of 100 meters (Ikhwani, 2021).

The results of the study showed that there was no relationship between psychomotor factors and swimming speed in athletes with disabilities. Research conducted by Matsuda et al., 2008 stated that after standing on a force plate for a predetermined period, the participant's static balance was measured using the centre of pressure on the feet. A similar technique was used in this investigation to assess the subject's static balance. Consequently, all static balance measurements showed no significant differences between the swimmers. A similar study conducted (Sugiura et al., 2014) examined how static balance parameters and data were generated. Regarding the parameters, no striking differences were found.

In the context of the research conducted, the negative correlation between anthropometric and biomotor factors with the swimming speed of disabled athletes from NPC Indonesia classified in the S7-S10 categories and who won medals at the ASEAN Para Games 2022 indicates that the closer an athlete's physical proportions and biomotor strength are to the established athletic standards, the better their swimming ability1. This means that athletes whose body size and muscle strength approach the ideal or generally recognized standards for swimming tend to perform better2. The negative correlation here indicates that improvements in meeting anthropometric and biomotor standards—such as ideal body height, proportional arm length, and optimal muscle strength—are inversely related to the time taken to complete a swimming distance; in other words, the closer they are to these standards, the faster they swim3. This underscores the importance of meeting certain physical standards to enhance efficiency and speed in swimming, especially for athletes with disabilities4.

In the domain of disability studies, the intricate relationship between physical characteristics and sports performance has been a subject of extensive research, particularly within the aquatic disciplines. The study by Lee et al. (2021) has brought to light the increased likelihood of both obesity and underweight conditions in individuals with disabilities, with a pronounced trend among women with severe or mental/developmental disabilities who are more prone to severe obesity. This highlights the critical role of anthropometric factors such as height, weight, body mass index, arm length, and leg length in influencing the health outcomes of these populations.

Additionally, the research by Bi et al. (2020) sheds light on the amplified susceptibility of individuals with disabilities to mental health issues, exacerbated by substandard living conditions, the need for specialized care, and a higher incidence of poverty and social isolation compared to the non-disabled population. This disparity underscores the importance of biomotor factors, including abdominal muscle strength and arm muscle power, as well as psychomotor factors measured by balance, in the overall well-being of individuals with disabilities.

In the context of the research conducted, the negative correlation between anthropometric and biomotor factors with the swimming speed of disabled athletes from NPC Indonesia, who are classified in categories S7-S10 and who won medals at the ASEAN Para Games 2022, indicates that the more proportional the physical size and biomotor strength of an athlete to the established athletic standards, the better their swimming ability. This means that athletes whose body size and muscle strength are close to the ideal standard or what is generally recognized for swimming tend to perform better (Morais, et al., 2021; Price, et al., 2024). The negative correlation here suggests that improvements in meeting anthropometric and biomotor standards—such as ideal body height, proportional arm length, and optimal muscle strength—are inversely related to the time needed to complete a swimming distance; in other words, the closer they are to these standards, the faster they swim (Price, et al., 2024). This emphasizes the importance of meeting certain physical standards to enhance efficiency and speed in swimming, especially for athletes with disabilities (Morais, et al., 2021; Price, et al., 2024).

Our investigation explores the connection between these variables and the swimming speed of disabled athletes, particularly those in the S7-S10 classification who have secured medals at the ASEAN Para Games in 2022. Our findings reveal a negative relationship between anthropometric and biomotor factors and the swimming speed of these athletes, indicating that an ideal body composition and muscle strength do not necessarily correlate with faster swimming speeds. In contrast, psychomotor factors, as determined through balance assessments, showed no significant link with swimming speed, challenging the traditional beliefs about the factors that contribute to aquatic proficiency in sports. This discrepancy between anticipated and actual performance outcomes in athletes with disabilities calls for a reassessment of training methods and support structures to align more closely with their distinct physiological and psychological characteristics. This study has several limitations that should be considered. Firstly, the research sample is limited to athletes with disabilities classified within the S7-S10 categories and who have won medals at the ASEAN Para Games 2022, which may not reflect the entire population of athletes with disabilities. Secondly, the study relies on anthropometric and biomotor measurements that may not fully capture the complexity of factors influencing swimming speed. Thirdly, although no significant relationship was found between psychomotor factors and swimming speed, the measurement methods used may not be sensitive enough to detect subtle nuances in athlete performance. Based on the identified limitations, we recommend several directions for future research. Further research with a larger and more diverse sample of athletes with disabilities could provide broader insights into the relationship between physical factors and athletic performance.

Additionally, the development and application of more sophisticated measurement methods for psychomotor factors could aid in understanding their influence on swimming speed. Finally, longitudinal research following athletes with disabilities over time could offer a deeper understanding of how anthropometric and biomotor factors interact and change with training and athlete development.

Conclusion

Based on the research results, it was concluded that anthropometric and biomotor factors showed a negative relationship with the swimming speed of disabled athletes from NPC Indonesia with the S7-S10 classification who got medals at the ASEAN Para Games event in 2022, while psychomotor factors did not show any relationship with the swimming speed of athletes with disabilities.

Conflict of interest

The authors declare no conflict of interest in this work

References

Alkhawaldeh, I. M., & Alzughilat, M. O. (2023). Extent of Knowledge and Application the Basics of Biomechanics Among Paralympic Games Coaches. International Journal of Disabilities Sports and Health Sciences, 6(3), 482–495. https://doi.org/10.33438/IJDSHS.1328438.

Bi, Y., Zhao, X., Zhou, Y., Lao, L., & Jiang, S. (2020). Factors associated with the depression among people with disabilities: A cross-sectional study in Chinese communities of Shanghai. Medicine, 99(47), e23331. https://doi.org/10.1097/MD.0000000000023331.

Bond, D., Goodson, L., Oxford, S.W., Nevill, A.M., Duncan, M.J. (2015). The Association between Anthropometric Variables, Functional Movement Screen Scores and 100 m Freestyle Swimming Performance in Youth Swimmers. Sports, 3, 1-11. https://doi.org/10.3390/sports3010001.

Born, D. P., Stöggl, T., Petrov, A., Burkhardt, D., Lüthy, F., & Romann, M. (2020). Analysis of Freestyle Swimming Sprint Start Performance After Maximal Strength or Vertical Jump Training in Competitive Female and Male Junior Swimmers. Journal of Strength and Conditioning Research, 34(2), 323–331. https://doi.org/10.1519/JSC.0000000000003390.

Canpolat, B., & Akyol, B. (2023). Paralympic Awareness of Sports Science Students: Example of TRB1 Region. International Journal of Disabilities Sports and Health Sciences, 6(1), 227–239. https://doi.org/10.33438/ijdshs.1355219.

Cratty, B.J., & Noble, C.E. (2022). Psychomotor Learning. Encyclopedia Britannica. https://www.britannica.com/science/psychomotor-learning.

Delas, S., Babin, J., & Katić, R. (2007). Effects of biomotor structures on performance of competitive gymnastics elements in elementary school female sixth-graders. Collegium antropologicum, 31(4), 979–985.

Engdahl-Høgåsen, L., & Bentzen, M. (2023). How is the participation of individuals with disabilities studied and understood in current research within the sport context? A systematic literature review. International Review of Sport and Exercise Psychology, 1–33. https://doi.org/10.1080/1750984X.2023.2261115.

Ersöz, G., & Esen, S. (2023). An Overview of Paralympic Sport from a Historical and Psychosocial Perspective. International Journal of Disabilities Sports and Health Sciences, 6(1), 475–489. https://doi.org/10.33438/ijdshs.1357682.

Fernandes, A., Afonso, J., Noronha, F., Mezêncio, B., Vilas-Boas, J. P., & Fernandes, R. J. (2023). Intracycle Velocity Variation in Swimming: A Systematic Scoping Review. Bioengineering, 10(3), 1–24. https://doi.org/10.3390/bioengineering10030308.

Gonjo, T., Fernandes, R. J., Vilas-Boas, J. P., & Sanders, R. (2021). Body roll amplitude and timing in backstroke swimming and their differences from front crawl at the same swimming intensities. Scientific Reports, 11(1), 1–12. https://doi.org/10.1038/s41598-020-80711-5.

González Palacio, E. V., Ramírez González, A. F., & Hernández Villa, A. M. (2022). Design and validation of three tests of aerobic power and speed in swimming children. Retos, 44, 1001–1008. https://doi.org/10.47197/retos.v44i0.87910.

Jiménez-Alfageme, R., Jordán, B. R., Camacho, J. D. H., Sospedra, I., Ferriz-Valero, A., Soriano, J. M., & Martínez-Sanz, J. M. (2022). Anthropometric profile in young swimmers. Cultura, Ciencia y Deporte, 17(52), 69–88. https://doi.org/10.12800/ccd.v17i52.1845.

Kauki, M. K., Prasetyo, Y., Rismayanthi, C., Asmuddin, A., Saman, A., Razali, M. N., Mustapha, A., Ali, S. K. S., Hutkemri, H., Sutapa, P., Hardianto, D., Auliana, R., Utami, D., Utami, D. Y., Riyana, A., Amran, A., Pratama, K. W., Trisnadi, R. A., & Astuti, A. T. (2024). Effect of Basic Water Confidence, Flexibility, and Technique on Freestyle Swimming Skill among Elementary School Pupils. Retos, 51, 1415–1423. https://doi.org/10.47197/retos.v51.101599.

Lee, D.-H., Kim, S. Y., Park, J. E., Jeon, H. J., Park, J.-H., & Kawachi, I. (2021). Nationwide trends in prevalence of underweight, overweight, and obesity among people with disabilities in South Korea from 2008 to 2017. International Journal of Obesity, 46(3), 613–622. https://doi.org/10.1038/s41366-021-01030-x.

Lui, C. W., & Lui, H. K. (2023). Who wins the paralympic medals? An analysis of the socio-economic determinants. Journal of Asian Business and Economic Studies, 30(4), 242–256. https://doi.org/10.1108/JABES-01-2022-0020.

Montejano Lozoya, R., Martínez-Alzamora, N., Clemente

Marín, G., Guirao-Goris, S. J. A., & Ferrer-Diego, R. M. (2017). Predictive ability of the Mini Nutritional Assessment Short Form (MNA-SF) in a free-living elderly population: a cross-sectional study. PeerJ, 5, e3345. https://doi.org/10.7717/peerj.3345.

Morais, J. E., Barbosa, T. M., Forte, P., Silva, A. J., & Marinho, D. A. (2021). Young Swimmers' Anthropometrics, Biomechanics, Energetics, and Efficiency as Underlying Performance Factors: A Systematic Narrative Review. Frontiers in Physiology, 12. https://doi.org/10.3389/fphys.2021.691919.

Morais, J. E., Barbosa, T. M., Nevill, A. M., Cobley, S., & Marinho, D. A. (2022). Understanding the Role of Propulsion in the Prediction of Front-Crawl Swimming Velocity and in the Relationship Between Stroke Frequency and Stroke Length. Frontiers in physiology, 13, 876838. https://doi.org/10.3389/fphys.2022.876838.

Post, A. K., Koning, R. H., Visscher, C., & Elferink-Gemser, M. T. (2023). Tracking performance and its underlying characteristics in talented swimmers: a longitudinal study during the junior-to-senior transition. Frontiers in Physiology, 14(August). https://doi.org/10.3389/fphys.2023.1221567.

Powell, L., Polsley, S., Casey, D., & Hammond, T. (2023). The Real-Time Classification of Competency Swimming Activity Through Machine Learning. International Journal of Aquatic Research and Education, 14(1). https://doi.org/10.25035/ijare.14.01.06.

Pranoto, A., Cahyono, M. B. A., Yakobus, R., Izzatunnisa, N., Ramadhan, R. N., Rejeki, P. S., Miftahussurur, M., Effendi, W. I., Wungu, C. D. K., & Yamaoka, Y. (2023). Long-Term Resistance-Endurance Combined Training . Reduces Pro-Inflammatory Cytokines in Young Adult Females with Obesity. Sports (Basel, Switzerland), 11(3), 54. https://doi.org/10.3390/sports11030054.

Price, T., Cimadoro, G., & Legg, H. S. (2024). Physical performance determinants in competitive youth swimmers: a systematic review. BMC Sports Science, Medicine and Rehabilitation, 16(1). https://doi.org/10.1186/s13102-023-00767-4.

Puce, L., Marinelli, L., Pierantozzi, E., Mori, L., Pallecchi, I., Bonifazi, M., Bove, M., Franchini, E., & Trompetto, C. (2018). Training methods and analysis of races of a top level Paralympic swimming athlete. Journal of Exercise Rehabilitation, 14(4), 612–620. https://doi.org/10.12965/jer.1836254.127.

Raharjo, S., Pranoto, A., Rejeki, P. S., Harisman, A. S. M., Pamungkas, Y. P., & Andiana, O. (2021). Negative Correlation between Serum Brain-derived Neurotrophic Factor Levels and Obesity Predictor Markers and Inflammation Levels in Females with Obesity. Open Access Macedonian Journal of Medical Sciences, 9(B), 1021-1026. https://doi.org/10.3889/oamjms.2021.6840.

Sellés-Pérez, S., Arévalo, H., Altavilla, C., Guerrero, D. J., & Cejuela, R. (2023). Effect of training with fins on swimming performance in kids and young recreational swimmers. Journal of Physical Education and Sport, 23(2), 532–537. https://doi.org/10.7752/jpes.2023.02066.

Verrelli, C. M., Romagnoli, C., Colistra, N., Ferretti, I., Annino, G., Bonaiuto, V., & Manzi, V. (2023). Golden ratio and self-similarity in swimming: breast-stroke and the back-stroke. Frontiers in Human Neuroscience, 17. https://doi.org/10.3389/fnhum.2023.1176866

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