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The relationship between physical condition and achievement rankings of East Java gymnastics athletes
La relación entre la condición física y las clasificaciones de logros de los atletas de gimnasia de Java Oriental

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Abstract. This research aims to analyze the relationship between the components of physical condition and the ranking of East Java (Indonesia) gymnastics athletes. This research was a cross-sectional study involving 14 gymnastics athletes at the National Sports Committee of Indonesia (KONI) regional training center in East Java Province (Indonesia), male (6 athletes) and female (8 athletes), aged 15-25 years. Data collection is carried out by measuring components of physical condition, which include strength, VO_2max, speed, power, agility, flexibility, and balance, which are measured at one time. Meanwhile, the score calculation for ranking athletes is based on the medals won by each athlete. The correlation test uses the Pearson product-moment model with a significance level of 5%. The results showed that there was a strong relationship between the components of physical condition and the ranking of East Java (Indonesia) gymnastics athletes ($p \leq 0.05$). Based on the research results, it can be concluded that physical conditions including strength, VO_2max, speed, power, agility, flexibility, and balance strongly correlate with the performance rankings of East Java (Indonesia) gymnastics athletes.
Keywords: Components of physical condition, athlete performance, gymnasts.

Resumen: Esta investigación tiene como objetivo analizar la relación entre los componentes de la condición física y el ranking de los atletas de gimnasia de Java Oriental (Indonesia). Esta investigación fue un estudio transversal que involucró a 14 atletas de gimnasia en el centro de entrenamiento regional del Comité Nacional de Deportes de Indonesia (KONI) en la provincia de Java Oriental (Indonesia), hombres (6 atletas) y mujeres (8 atletas), con edades entre 15 y 25 años. . La recopilación de datos se lleva a cabo midiendo componentes de la condición física, que incluyen fuerza, VO2max, velocidad, potencia, agilidad, flexibilidad y equilibrio, que se miden al mismo tiempo. Mientras tanto, el cálculo de la puntuación para la clasificación de los atletas se basa en las medallas ganadas por cada atleta. La prueba de correlación utiliza el modelo producto-momento de Pearson con un nivel de significancia del 5%. Los resultados mostraron que había una fuerte relación entre los componentes de la condición física y la clasificación de los atletas de gimnasia de Java Oriental (Indonesia) ($p \leq 0,05$). Con base en los resultados de la investigación, se puede concluir que las condiciones físicas, incluidas la fuerza, el VO2máx, la velocidad, la potencia, la agilidad, la flexibilidad y el equilibrio, se correlacionan fuertemente con las clasificaciones de rendimiento de los atletas de gimnasia de Java Oriental (Indonesia).
Palabras clave: Componentes de la condición física, rendimiento de atletas, gimnastas.

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Introduction

The realm of gymnastics, with its captivating blend of artistry and athleticism, is a testament to human physical potential. This study begins a focused analytical journey to examine the key factors contributing to gymnasts' success in East Java, Indonesia. More than mere observation, this research seeks to distill the core elements that drive excellence in this demanding sport (Kogoya et al., 2022).

Gymnastics is a multifaceted discipline, comprising distinct branches—artistic, rhythmic, and trampoline gymnastics—each with its unique set of physical and technical demands. Artistic gymnastics requires explosive power and precise coordination, rhythmic gymnastics emphasizes grace and flexibility, while trampoline gymnastics demands acute spatial awareness and dynamic control (Setiawan et al., 2019). Each of these branches calls for the mastery of different physical and mental attributes, highlighting the diverse range of capabilities gymnasts must develop to succeed.

The National Sports Committee of Indonesia (KONI) of East Java Province has recognized the importance of nurturing gymnastic talent. To this end, KONI has established regional training centers (Puslatda) to prepare athletes for high-level competitions such as the National Sports Event (PON) and National Championships. However, the athlete selection process for these centers has been hindered by systemic challenges, including limited financial resources and a lack of objective, standardized selection criteria. This has introduced biases, conflicts, and subjectivity into the recruitment process, undermining the fairness and transparency essential to athlete development (Seran et al., 2020).

In response to these challenges, this study aims to propose a clear, structured, and scientific approach to the selection and development of gymnasts in East Java. The goal is to establish a transparent, accountable framework that ensures objectivity and eliminates the influence of personal biases in athlete recruitment. By incorporating insights from international research and adopting best practices, this study seeks to develop a selection model that is based on measurable, observable, and replicable criteria. This new model is intended to promote a sustainable, merit-based approach to sports development that can withstand scrutiny and produce consistently fair outcomes (Aldapit et al., 2023).

This study aims to analyze the relationship between various physical condition components—strength, VO_2max, speed, power, agility, flexibility, and balance—and the competitive rankings of gymnasts in East Java, Indonesia. The study involves both male and female gymnasts from the KONI regional training center in East Java. Using the Pearson product-moment correlation test, this research assesses the strength of the relationship between the athletes' physical conditions and their rankings, which are based on the number of medals won. This approach aims to provide deeper insights into the physical factors influencing the success of gymnasts in competitive settings.

Material and Methods

Study design, population and sample

This study used an analytical observational method with a design cross-sectional study involving 14 gymnastics athletes at the KONI regional training center in East Java Province (Indonesia), male (6 athletes) and female (8 athletes), aged 15-25 years, at least have participated in a provincial level championship, and been a professional athlete for more than 5 years. The population and sample used in this research were athletes undergoing training camps in East Java. The sampling technique in this research used purposive sampling. Data collection was carried out after obtaining approval from parents by filling out and signing informed consent which was carried out in a conscious state. Before participating in the research, all subjects were also explained about the aims, benefits and procedures of this research both orally and in writing.

Data collection

Data collection was carried out by measuring components of physical condition which include strength, VO_2max, speed, power, agility, flexibility and balance which are measured at one time (morning) for one week. The instruments used to measure physical condition components can be seen in Table 1 below. Determination of the medal of score for each levels was based on the results of the Focus Group Discussion (FGD) of gymnastics coaches throughout East Java (Indonesia), while the calculation of the athlete ranking score was based on the medals obtained by each athlete which are presented in Table 2. Certificates or medals obtained for ranking for a maximum of the last 2 years.

Table 1.
Physical condition component instrument

No	Components of Physical Condition	Instrument	References
1	Leg Strength (kg)	Back and Leg Dynamometer Test	Putera et al., 2023
2	Upper Strength Endurance Push (times)	Push Up Fitness Test (60 s)	Hassan, 2018
3	Upper Strength Endurance Pull (times)	Pull-Up Test (60 s)	Coyne et al., 2015
4	Abs Strength Endurance (m)	Sit Up Test (60 s)	Bianco et al., 2015
5	Back Strength Endurance (times)	Back Up Test (60 s)	Kim et al., 2023
6	VO_2max (mL/kg/min)	Multistage 20-m Shuttle Run Test	Magee et al., 2021
7	Speed (s)	20m Sprint Test	Sinclair et al., 2021
8	Reaction Time (cm)	Ruler drop test	Del Rossi et al., 2014
9	Lower Body Power (cm)	Jump MD test	Putera et al., 2023
10	Upper Body Power (cm)	Seated Medicine Ball "Power" Throw (3 kg) test	Harris et al., 2011
11	Abs Power (cm)	Lying Medicine Ball Throw (3kg) test	Barbosa et al., 2024
12	Agility (s)	Square Jump	Jakiwa et al., 2023
13	Flexibility (cm)	Sit and Reach Test	Mayorga-Vega et al., 2014
14	R Flex Shoulder Right (cm)	Shoulder Reach Flexibility Test	Vernetta et al., 2022
15	R Flex Shoulder Left (cm)		
16	R Flexi Wrist Right (degrees)	Wrist Flexion Manual Muscle Test	Decostre et al., 2015
17	R Flexi Wrist Left (degrees)		
18	Static Balance (s)	Stork Balance Stand Test	Shushtari et al., 2022
19	Dinamic Balance (s)	Y Balance Test (YBT)	Lee & Ahn, 2018

Table 2.
Calculation of athlete ranking scores based on medal wins

No	Medals	Levels		
		Area	National	International
1	Gold	10	20	30
2	Silver	7	16	25
3	Bronze	4	12	20

Statistical analysis

Statistical analysis uses descriptive analysis by displaying mean data, standard deviation (SD) for each variable. Test data normality using the Shapiro–Wilk test. Meanwhile, normally distributed data then correlation test using the Pearson product moment model which was carried out with Statistical Package for the Social Sciences (SPSS) for Windows, version 26 (SPSS Inc., Chicago, IL, USA) with a significance level of 5%.

Results

The results of the descriptive analysis of the characteristics of the research subjects are described in Table 3. Meanwhile,

the results of the correlation analysis between physical condition and athlete performance rankings are presented in Table 4.

Table 3.
Descriptive analysis of research subject characteristics

Parameters	n	Mean	Standard Deviation	Percentage (%)
Sex:				
Male	6	-	-	42.86
Female	8			57.14
Total	14			100.00
Gymnastics category:				
Artistic	8			57.14
Aerobic	3	-	-	21.43
Rhythmic	3			21.43
Total	14			100.00
Age (yrs)	14	18.86	3.48	-
Height (m)	14	1.58	0.05	-
Weight (kg)	14	47.47	5.72	-
Body mass index (kg/m^2)	14	19.05	1.44	-
Rating (score)	14	20.50	9.09	-
Leg Strength (kg)	14	89.29	34.95	-
Upper Strength Endurance Push (times)	14	29.29	8.84	-
Upper Strength Endurance Pull (times)	14	18.64	2.71	-
Abs Strength Endurance (m)	14	35.50	5.68	-
Back Strength Endurance (times)	14	39.07	7.38	-
VO_2max (mL/kg/min)	14	39.11	5.37	-
Speed (s)	14	3.87	0.35	-
Reaction Time (cm)	14	12.34	3.05	-
Lower Body Power (cm)	14	62.43	11.29	-
Upper Body Power (cm)	14	3.83	0.75	-
Abs Power (cm)	14	3.27	1.25	-
Agility (s)	14	5.98	0.86	-
Flexibility (cm)	14	40.04	7.77	-
R Flex Shoulder Right (cm)	14	1.75	0.96	-
R Flex Shoulder Left (cm)	14	1.54	0.60	-
R Flexi Wrist Right (degrees)	14	65.86	6.70	-
R Flexi Wrist Left (degrees)	14	72.07	8.91	-
Static Balance (s)	14	105.81	69.92	-
Dinamic Balance (s)	14	87.89	4.09	-

Table 4.
The relationship between physical condition and athlete performance rankings

Parameters	Rating (score)	
	r	*p*-Value
Leg Strength (kg)	0.748**	p ≤ 0.001
Upper Strength Endurance Push (times)	0.880**	p ≤ 0.001
Upper Strength Endurance Pull (times)	0.637*	0.014
Abs Strength Endurance (m)	0.831**	p ≤ 0.001
Back Strength Endurance (times)	0.859**	p ≤ 0.001
VO_2max (mL/kg/min)	0.603*	0.022
Speed (s)	-0.708**	p ≤ 0.001
Reaction Time (cm)	-0.837**	p ≤ 0.001
Lower Body Power (cm)	0.897**	p ≤ 0.001
Upper Body Power (cm)	0.816**	p ≤ 0.001
Abs Power (cm)	0.960**	p ≤ 0.001
Agility (s)	-0.784**	p ≤ 0.001
Flexibility (cm)	0.759**	p ≤ 0.001
R Flex Shoulder Right (cm)	-0.830**	p ≤ 0.001
R Flex Shoulder Left (cm)	-0.796**	p ≤ 0.001
R Flexi Wrist Right (degrees)	-0.868**	p ≤ 0.001
R Flexi Wrist Left (degrees)	-0.559*	0.038
Static Balance (s)	0.934**	p ≤ 0.001
Dinamic Balance (s)	0.906**	p ≤ 0.001

* Significant with p ≤ 0.05.
** Significant with p ≤ 0.001.

Based on the correlation test results, it shows that there was a positive relationship between Rating and Leg Strength, Upper Strength Endurance Push, Upper Strength Endurance Pull, Abs Strength Endurance, Back Strength Endurance, VO_2max, Lower Body Power, Upper Body Power, Abs Power, Flexibility, Static Balance, and Dynamic Balance. Interestingly, we also found a negative relationship between Rating and Speed, Reaction Time, Agility, R Flex Shoulder Right, R Flex Shoulder Left, R Flexi Wrist Right, and R Flexi Wrist Left.

Discussion

Gymnastics is widely recognized for its potential to enhance children's growth and development, serving as a foundational sport that emphasizes skilled and proficient movement control (Sulistyowati et al., 2022). The talent search has been identified as an effective method for selecting young individuals with robust bio-motor abilities (Mann, et al., 2017). It has been observed that motor abilities in athletes and gymnasts are generally more advanced than those in the average child population of the same age. This aligns with previous studies that have noted similar developments at comparable stages of sports career progression (Solum et al., 2020; Paunović et al., 2019; Dobrijević et al., 2020; Stanković et al., 2020). Notably, 9 to 12 years is critical for developing children's motor skills (Balyi and Hamilton, 2004; Solum et al., 2020). However, it is important to acknowledge that our study's methodology, particularly in selecting and testing participants, may have introduced biases that could influence these observations. The specific limitations and their potential impact on our findings are discussed in detail in the Materials and Methods section.

Our results demonstrate a strong correlation between physical condition variables (strength, VO_2max, speed, power, agility, flexibility, and balance) and athlete performance ratings (Table 4). This is supported by Sukamti et al. (2020), who highlighted the significance of physical fitness in gymnastics, demonstrating incremental improvements in flexibility, speed, strength, agility, and endurance among trained gymnasts compared to untrained individuals over time. Donti et al. (2014) further found that short-term, focused training programs significantly enhance motor skills and fitness, particularly in young gymnasts, reinforcing the importance of strength and power for high performance.

Flexibility has been recognized as a crucial physical attribute in gymnastics. Skopal et al. (2020) emphasized that flexibility contributes to executing complex gymnastic movements, such as splits and bridges, which is consistent with our findings. Additionally, Elferink-Gemser et al. (2012) highlighted the role of VO_2max and overall endurance in optimizing performance, supporting our conclusion that aerobic capacity is a key determinant of success in gymnastics. Collectively, these studies align with our results, affirming that improvements in strength, agility, flexibility, and endurance are

crucial for gymnastics performance.

The success of artistic gymnastics depends mainly on achieving an optimal balance between physical fitness and the complex technical skills required for each apparatus. Therefore, achieving extraordinary levels of total physical performance is essential for male gymnasts (Agopyan & Örs, 2019). Intervention programs involving physical activity have significantly improved fitness, strength, and cardiorespiratory balance (Sumaryanti et al., 2019).

Physical activity improves health-related abilities. Several widely recognized fitness assessments evaluate various aspects of health in young individuals (Elferink-Gemser et al., 2012). However, increasing the capacity to accurately assess strength, power, speed, balance, flexibility, and agility may also assist in identifying and addressing deficiencies in the fundamental physical performance attributes required in gymnastics, as demonstrated by certain studies focused on fitness development. (Trajković et al., 2016).

The definition of physical preparation in gymnastics should primarily consider the fulfillment of specific favorable conditions that increase coordination capacity during technical preparation (Kochanowicz et al., 2009; Atilgan, 2013; Sawczyn et al., 2016). Developing expertise in certain aspects and routines of gymnastics requires a high level of understanding and utilization of one's physical strength and endurance. (Sawczyn et al., 2016). Additionally, it is widely known that increasing the cross-sectional surface area of muscles is critical to achieving optimal strength gains in young and adult individuals. (Burt et al., 2013). The main requirements in artistic gymnastics relate to muscle strength and power, which significantly facilitates coordination abilities. Gymnasts demonstrate extraordinary strength when measured in relative strength, which compares their strength to body weight (Sawczyn et al., 2016). This is seen in their ability to support and manipulate body weight in various dynamic or static postures (Sawczyn et al., 2016). Upper limb strength is essential for vaulting, horse-stroke, parallel bars, and rings, especially for static resistance elements such as iron crosses, inverted crosses, and swallows. Muscle growth is essential for strength, but it is vital to avoid turning gymnastic fitness into bodybuilding (Malina et al., 2013). Therefore, muscle dimensions ultimately limit strength gains, specifically their size and cross-sectional area. Developing muscle size and strength is very important in gymnastics, but the main training goal is to maximize strength while minimizing muscle size (Sawczyn et al., 2016). To maximize a gymnast's strength-to-body mass ratio, it is essential to control hypertrophy within strict limits (Kolar & Podlogar, 2017).

Aerobic endurance serves as a foundation for developing specific skills (Yunus et al., 2024). In addition, aerobic strength is considered an essential factor in determining gymnastics success (Oliveira et al., 2022; Sleeper et al., 2012). Some experts argue that aerobic strength is not the most critical factor and suggest developing it through anaerobic training (Jemni et al., 2006). Nevertheless, the VO_2max of international gymnasts has remained relatively constant at around 50 mL/kg/min over the last five decades despite increases in the difficulty and intensity of gymnastics routines (George et al., 2013).

Flexibility is a fundamental physical attribute that is important for practicing Rhythmic Gymnastics (Freiré Maceiras et a., 2023). Elite gymnasts who are members of the National Team are expected to demonstrate extraordinary motor skills (Santos et al., 2015). Flexibility refers to the range of motion of a joint, indicating that greater joint mobility results in greater flexibility. The main focus of rhythmic gymnastics is the ability to demonstrate extraordinary flexibility in forward and backward body movements, such as sitting positions and reaching and bridging. (Sulistyowati et al., 2022). Implementing gymnastics depends on flexibility because it requires the ability to assume certain body positions to carry out gymnastic exercises that require a wide range of motion. The importance of flexibility requirements differentiates gymnastics from other sports. The hip joint is the main joint requiring increased range of motion in both men and women (George, et al., 2013). This joint is very important during exercise routines because it usually functions when performing activities with extended legs. The results of our study showed comparable flexibility measurements between female and male gymnasts (36.44 ± 4.24 vs. 34.18 ± 3.40 cm), indicating that flexibility is an important performance factor for both sexes. Gymnasts have much greater flexibility than soccer players and volleyball players when compared to other athletes (Duncan et al., 2006; Ostojic & Stojanovic, 2007).

Balance refers to the capacity to maintain stability while standing on one leg or being in the air without swaying during static or dynamic actions that challenge balance. Balance plays an important role in gymnastics because it involves maintaining a balance between body positions and movements and using various instruments. Early childhood children can develop basic static balance skills through training in this sport (Sulistyowati et al., 2022).

In artistic gymnastics, significant running speed is essential for challenging jumps (Schärer et al., 2019). Speed plays a vital role in the approach to the vault and during floor routines, allowing you to reach maximum speed and traverse the distance as quickly as possible. However, greater speed during the approach is generally required to perform more challenging jumps and increase the chances of obtaining a high final score (Schärer et al., 2019). A run-up vault is traditionally defined as an acceleration of 20 meters, followed by a period of maintaining speed for 5 meters, to achieve ideal contact with the vault board and execute the planned vault successfully. (Schärer et al., 2019). In addition, Veličković et al. (2011) found that highly competent gymnasts showed different speed

patterns during the vaulting process, in contrast to less advanced gymnasts. However, the vault run-up appears to be a tightly regulated sprint aimed at a specific target. This is due to the short initial distance and complex execution of skills at the end. However, the importance of stride kinematics in achieving fast running speeds and executing challenging jumps remains uncertain. In addition, the precise impact of physical factors, such as running speed, explosive power (muscle power, rate of force generation), and reactive power (performance in short (≤200 ms) strain shortening cycles) in achieving high running speeds. the rate of rise is still not fully understood. Typically, in sports such as athletics and football, the critical factors for achieving high running speeds in short linear sprints are stride kinematics, explosive power, and reactive power (Meyers et al., 2017). In artistic gymnastics, the importance of lower body strength, including running speed, explosive strength, and reactive strength, is widely recognized as critical to success in the long jump (Schärer et al., 2019).

Agility refers to an individual's capacity to quickly change direction and position while performing other movements. Agility is essential in rhythmic gymnastics because athletes must demonstrate agility and proficiency in performing various exercises, both with and without equipment, while synchronizing with music. Apart from that, they must be able to quickly and consistently change their direction according to the rhythm (Sulistyowati et al., 2022). The main movement patterns in agility gymnastics include landing, static positioning, movement, jumping, hovering, and swinging (Putra et al., 2023).

In conclusion, our study underscores the intricate interplay between physical fitness and technical skill in artistic gymnastics, highlighting the importance of strength, power, and aerobic capacity in enhancing performance. While our findings contribute valuable insights into the physical attributes that underpin gymnastic success, it is crucial to interpret these results within the confines of our methodological approach. The limitations outlined in the Materials and Methods section require cautious extrapolation of our conclusions. Future research should address these limitations, providing a more robust framework for evaluating the impact of physical fitness on gymnastic performance. By doing so, we can continue refining our understanding of the factors contributing to excellence in this demanding sport.

Conclusion

The findings of this study indicate a strong correlation between the physical attributes of gymnasts—such as strength, VO_2max, speed, power, agility, flexibility, and balance—and their competitive rankings in East Java, Indonesia. These results support the idea that optimizing these key physical components can enhance athletic performance and contribute to a gymnast's competitive edge. However, it is important to acknowledge several limitations of the study. The relatively small sample size and cross-sectional design may limit the generalizability of the findings and preclude drawing definitive conclusions about causality. Furthermore, the measurements of physical attributes were taken at a single point in time, which may not fully reflect the dynamic nature of physical conditioning over a training period or during competition.

Future research should address these limitations by employing larger sample sizes and using longitudinal or experimental designs to better understand how physical attributes evolve over time and their causal impact on performance. Additionally, exploring other factors such as psychological readiness and nutrition could provide a more comprehensive understanding of what contributes to gymnastic success. By addressing these areas, future studies can offer more robust evidence to guide athlete development and performance optimization in gymnastics.

Conflict of interest

The authors declare that they have no competing interests.

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References

Agopyan, A., & Örs, B. S. (2019). An analysis of variations in body movement difficulty of 2016 Olympic Games rhythmic gymnast candidates. *International Journal of Performance Analysis in Sport, 19*(3), 417–434. https://doi.org/10.1080/24748668.2019.1617017.

Aldapit, E., Juntara, P. E., Yulisatria, G., Malasari, C. A., & Azni, N. (2023). Sports Coaching and Talent Scouting in Indonesia. *International Conference on Science, Education, and Technology,* 7(1), 146–149. Retrieved from https://proceeding.unnes.ac.id/ISET/article/view/1949.

Atilgan, O. E. (2013). Effects of trampoline training on jump, leg strength, static and dynamic balance of boys. *Science of Gymnastics Journal, 5*(2), 15–25.

Balyi, I., & Hamilton, A. (2004). Long-term athlete development: trainability in childhood and adolescence. Windows of opportunity. Optimal trainability. Victoria: National Coaching Institute British Columbia & Advanced Training and Performance Ltd in *The Scottish Strength and Conditioning Seminar in Largs*, p. 194.

Bianco, A., Lupo, C., Alesi, M., Spina, S., Raccuglia, M.,

Thomas, E., Paoli, A., & Palma, A. (2015). The sit up test to exhaustion as a test for muscular endurance evaluation. *SpringerPlus, 4*, 309. https://doi.org/10.1186/s40064-015-1023-6.

Barbosa, G. M., Calixtre, L. B., Fonseca Fialho, H. R., Locks, F., & Kamonseki, D. H. (2024). Measurement properties of upper extremity physical performance tests in athletes: a systematic review. *Brazilian journal of physical therapy, 28*(1), 100575. https://doi.org/10.1016/j.bjpt.2023.100575.

Burt, L. A., Greene, D. A., Ducher, G., & Naughton, G. A. (2013). Skeletal adaptations associated with pre-pubertal gymnastics participation as determined by DXA and pQCT: a systematic review and meta-analysis. *Journal of science and medicine in sport*, *16*(3), 231–239. https://doi.org/10.1016/j.jsams.2012.07.006.

Coyne, J.O., Tran, T., Secomb, J.L., Lundgren, L., Farley, O.R., Newton, R., & Sheppard, J.M. (2015). Reliability of pull up and dip maximal strength tests. *Journal of Australian Strength and Conditioning, 23*(4), 21-27.

Del Rossi, G., Malaguti, A., & Del Rossi, S. (2014). Practice effects associated with repeated assessment of a clinical test of reaction time. *Journal of athletic training, 49*(3), 356–359. https://doi.org/10.4085/1062-6059-49.2.04.

Decostre, V., Canal, A., Ollivier, G., Ledoux, I., Moraux, A., Doppler, V., Payan, C. A., & Hogrel, J. Y. (2015). Wrist flexion and extension torques measured by highly sensitive dynamometer in healthy subjects from 5 to 80 years. *BMC musculoskeletal disorders, 16*(1), 4. https://doi.org/10.1186/s12891-015-0458-9.

Dobrijević, S., Ćosić, M., Pajić, S.K., Grujić, S., & Moskovljević, L. (2020). The Development of Motor Abilities of Young Athletes and Gymnasts in the Initial Preparation Phase. *Facta Universitatis, Series: Physical Education and Sport, 18*(2), https://doi.org/10.22190/fupes200323047d.

Donti, O., Tsolakis, C., & Bogdanis, G. C. (2014). Effects of baseline levels of flexibility and vertical jump ability on performance following different volumes of static stretching and potentiating exercises in elite gymnasts. *Journal of sports science & medicine*, *13*(1), 105–113.

Duncan, M. J., Woodfield, L., & al-Nakeeb, Y. (2006). Anthropometric and physiological characteristics of junior elite volleyball players. *British journal of sports medicine*, *40*(7), 649–651. https://doi.org/10.1136/bjsm.2005.021998.

Elferink-Gemser, M. T., Huijgen, B. C., Coelho-e-Silva, M., Lemmink, K. A., & Visscher, C. (2012). The changing characteristics of talented soccer players--a decade of work in Groningen. *Journal of sports sciences*, *30*(15), 1581–1591. https://doi.org/10.1080/02640414.2012.725854.

Freiré Maceiras , R., Fernández Villarino, M., & Sierra Palmeiro, E. (2023). Components of performance in individual rhythmic gymnastics. *Retos, 49*, 16–21. https://doi.org/10.47197/retos.v49.97981.

George, D., Elias, Z., & George, P. (2013). Physiological profile of elite Greek gymnasts. *Journal of Physical Education and Sport, 13*(1), 27–32. https://doi.org/10.7752/jpes.2013.01005.

Harris, C., Wattles, A. P., DeBeliso, M., Sevene-Adams, P. G., Berning, J. M., & Adams, K. J. (2011). The seated medicine ball throw as a test of upper body power in older adults. *Journal of strength and conditioning research, 25*(8), 2344–2348. https://doi.org/10.1519/JSC.0b013e3181ecd27b.

Hassan, S. (2018). The Effects of Push-Up Training on Muscular Strength and Muscular Endurance. *International Journal of Academic Research in Business and Social Sciences, 8*(11), 660-665. https://doi.org/10.6007/IJARBSS/v8-i11/4940.

Jakiwa, J., Rustam, S., Atan, S.A., Azli, M.S., Maliki, A.B.H.M., Nadzmi, A., Abd Rahman, A.F., Samsir, M.S., Sun, Z., Kuo, P.T., Tan Sing Bee, N.C. (2023). The Effects of Multi-Sport Intervention on Agility Performance among Young Athletes. *International Journal of Human Movement and Sports Sciences, 11*(4), 864-871. https://doi.org/10.13189/saj.2023.110421.

Jemni, M., Sands, W. A., Friemel, F., Stone, M. H., & Cooke, C. B. (2006). Any effect of gymnastics training on upper-body and lower-body aerobic and power components in national and international male gymnasts?. *Journal of strength and conditioning research*, *20*(4), 899–907. https://doi.org/10.1519/R-18525.1.

Kim, T., Kim, G., Park, H. W., Kang, E. K., & Baek, S. (2023). Back Extensor Strength as a Potential Marker of Frailty Using Propensity Score Matching and Machine Learning. *Journal of clinical medicine, 12*(19), 6156. https://doi.org/10.3390/jcm12196156.

Kochanowicz, A., Kochanowicz, K., & Sawczyn, S. (2009). Special Fitness and the Effectiveness of Technical Preparation in Gymnastic Vault Event in Athletes at the Directed Stage', *Baltic Journal of Health and Physical Activity, 1*(1), 70–78. https://doi.org/10.2478/v10131-009-0008-7.

Kogoya, K., Guntoro, T.S., & Putra, M.F.P. (2022). Sports Event Image, Satisfaction, Motivation, Stadium Atmosphere, Environment, and Perception: A Study on the Biggest Multi-Sport Event in Indonesia during the Pandemic. *Social Sciences, 11*(6), 241. https://doi.org/10.3390/socsci11060241.

Kolar, J., & Podlogar, T. (2017). Optimization of training for muscle hypertrophy and its implication into gymnastics. *Conference: 4th International Scientific Congress Slovenian Gymnastics Federation*.

Lee, S. K., & Ahn, S. H. (2018). Effects of balance evaluation

comparison of dynamic balance and Y balance. *Journal of exercise rehabilitation, 14*(6), 939–943. https://doi.org/10.12965/jer.1836494.247.

Magee, M. K., White, J. B., Merrigan, J. J., & Jones, M. T. (2021). Does the Multistage 20-m Shuttle Run Test Accurately Predict VO2max in NCAA Division I Women Collegiate Field Hockey Athletes?. *Sports (Basel, Switzerland), 9*(6), 75. https://doi.org/10.3390/sports9060075.

Malina, R. M., Baxter-Jones, A. D., Armstrong, N., Beunen, G. P., Caine, D., Daly, R. M., Lewis, R. D., Rogol, A. D., & Russell, K. (2013). Role of intensive training in the growth and maturation of artistic gymnasts. *Sports medicine (Auckland, N.Z.)*, *43*(9), 783–802. https://doi.org/10.1007/s40279-013-0058-5.

Mann, D. L., Dehghansai, N., & Baker, J. (2017). Searching for the elusive gift: advances in talent identification in sport. *Current opinion in psychology*, *16*, 128–133. https://doi.org/10.1016/j.copsyc.2017.04.016.

Mayorga-Vega, D., Merino-Marban, R., & Viciana, J. (2014). Criterion-Related Validity of Sit-and-Reach Tests for Estimating Hamstring and Lumbar Extensibility: a Meta-Analysis. *Journal of sports science & medicine, 13*(1), 1–14.

Meyers, R.W., Oliver, J.L., Hughes, M.G., Lloyd, R.S., & Cronin, J.B. (2017). New insights into the development of maximal sprint speed in male youth. *Strength and Conditioning Journal, 39*(2), 2–10. https://doi.org/10.1519/SSC.0000000000000290.

Oliveira, V. dos S. de, Vieira-Souza, L. M., Getirana-Mota, M., Dos Santos, J. L., Aidar, F. J., Lima Júnior, C. M. A., Reis, G. C., & Silva, F. J. A. da. (2022). Labor gymnastics: promotion of health and performance for work in industrial workers. *Retos, 44*, 1180–1185. https://doi.org/10.47197/retos.v44i0.90711.

Ostojic, S., & Stojanovic, M.D. (2007). Range Of Motion In The Lower Extremity: Elite Vs. Non-Elite Soccer Players. *Serbia Jornal of Sport Science, 1*(2), 74–78.

Paunović, M., Đurović, M., Veličković, S., Živković, M., Stojanović, N. (2019) The Explosive Strength of Girls of the Younger School Age. *Facta Universitatis, Series: Physical Education and Sport, 16*(3), 677–685. https://doi.org/10.22190/fupes171022046p.

Putera, S. H. P., Setijono, H., Wiriawan, O., Nurhasan, Muhammad, H. N., Hariyanto, A., Sholikhah, A. M., & Pranoto, A. (2023). Positive Effects of Plyometric Training on Increasing Speed, Strength and Limb Muscles Power in Adolescent Males. *Physical Education Theory and Methodology, 23*(1), 42–48. https://doi.org/10.17309/tmfv.2023.1.06.

Putra, R.B.A., Priyono, B., Soenyoto, T., Darmawan, A., & Supaat, S. (2023). Dominant Motion Patterns of Gymnastics Activities for Elementary School in *ISPHE 2022*. https://doi.org/10.4108/eai.29-6-2022.2326131.

Santos, A.B., Lemos, M.E., Lebre, E., Carvalho, L.A. (2015) 'Active and passive lower limb flexibility in high level rhythmic gymnastics. *Science of Gymnastics Journal, 7*(2), 55–66.

Sawczyn, S., Zasada, M., Kochanowicz A., Niespodzinsk, B., & Sawczyn, M. (2016). The effect of specific strength training on the quality of gymnastic elements execution in young gymnasts. *Baltic Journal of Health and Physical Activity, 8*(4), 79–91. https://doi.org/10.29359/bjhpa.08.4.09.

Schärer, C., Haller, N., Taube, W., & Hübner, K. (2019). Physical determinants of vault performance and their age-related differences across male junior and elite top-level gymnasts. *PloS one, 14*(12), e0225975. https://doi.org/10.1371/journal.pone.0225975.

Schärer, C., Lehmann, T., Naundorf, F., Taube, W., & Hübner, K. (2019). The faster, the better? Relationships between run-up speed, the degree of difficulty (D-score), height and length of flight on vault in artistic gymnastics. *PloS one*, *14*(3), e0213310. https://doi.org/10.1371/journal.pone.0213310.

Seran, Y.A.M., Rumini., & Soegiyanto. (2020). Management of Kempo Sport Department Achievements Development Program in Belu Regency, East Nusa Tenggara. *Journal of Physical Education and Sports, 9*(3), 228–234.

Setiawan, A., Saputra, Y.M., Ma'mu, A., & Fattah, N. (2019). Sports Development in West Java: Sports policy review. Proceedings of the 3rd International Conference on Sport Science, Health, and Physical Education (ICSSHPE 2018). *Advances in Health Sciences Research, 11*, 262-265. https://doi.org/10.2991/icsshpe-18.2019.75.

Shushtari, M., Takagi, A., Lee, J., Burdet, E., & Arami, A. (2022). Balance strategy in hoverboard control. *Scientific reports, 12*(1), 4509. https://doi.org/10.1038/s41598-022-08291-0.

Sinclair, J., Edmundson, C. J., Metcalfe, J., Bottoms, L., Atkins, S., & Bentley, I. (2021). The Effects of Sprint vs. Resisted Sled-Based Training; an 8-Week in-Season Randomized Control Intervention in Elite Rugby League Players. *International journal of environmental research and public health, 18*(17), 9241. https://doi.org/10.3390/ijerph18179241.

Skopal, L., Netto, K., Aisbett, B., Takla, A., & Castricum, T. (2020). The Effect of A Rhythmic Gymnastics-Based Power-Flexibility Program on The Lower Limb Flexibility And Power of Contemporary Dancers. *International journal of sports physical therapy, 15*(3), 343–364.

Sleeper, M. D., Kenyon, L. K., & Casey, E. (2012). Measuring fitness in female gymnasts: the gymnastics functional measurement tool. *International journal of sports physical therapy*, *7*(2), 124–138.

Solum, M., Lorås, H., & Pedersen, A. V. (2020). A Golden Age for Motor Skill Learning? Learning of an Unfamiliar Motor Task in 10-Year-Olds, Young Adults, and Adults,

When Starting From Similar Baselines. *Frontiers in psychology, 11*, 538. https://doi.org/10.3389/fpsyg.2020.00538.

Stanković, S., Veljković, A.A., Marković, Z., Herodek, K. (2020). The Effects of Regular Classes and Classes With Additional Exercises on Students' Motor Abilities. *Facta Universitatis, Series: Physical Education and Sport, 18*(1), 219–228. https://doi.org/10.22190/fupes190410019s.

Sukamti, E. R., Budiarti, R., & Nurfadhila, R. (2020). Effect of physical conditioning on student basic skills gymnastics. *Cakrawala Pendidikan, 39*(1), 207–216. https://doi.org/10.21831/cp.v39i1.29641.

Sulistyowati, E.M., Suherman, W.S., Sukamti, E.R., Rahmatullah, M.I., Mitsalina, D. (2022). Specifics of Basic Biomotor Components for Rhythmic Gymnastics. Proceedings of the Conference on Interdisciplinary Approach in Sports in conjunction with the 4th Yogyakarta International Seminar on Health, Physical Education, and Sport Science (COIS-YISHPESS 2021). *Atlantis Press, 27*(30), 2468–5739. https://doi.org/10.2991/ahsr.k.220106.004.

Sumaryanti, Tomoliyus., & Ndayisenga, J. (2019). Circuit training intervention for adaptive physical activity to improve cardiorespiratory fitness, leg muscle strength static and balance of intellectually disabled children. *Sport Mont, 17*(3), 97–100. https://doi.org/10.26773/smj.191019.

Trajkovic, N., Madic, D., Sporis, G., Aleksic-Veljkovic, A., Zivcic-Markovic, K. (2016). Impact of gymnastics program on health-related fitness in adolescent pupils. *Science of Gymnastics Journal, 8*(2), 157–166.

Veličković, S., Petković, D., & Petković, E. (2011). A Case Study About Differences in Characteristics of the Run-Up Approach on the Vault Between Top-Class and Middle-Class Gymnasts. *Science of Gymnastics Journal, 3*(1), 25–34.

Vernetta, M., Peláez-Barrios, E. M., & López-Bedoya, J. (2022). Systematic review of flexibility tests in gymnastics. *Journal of Human Sport and Exercise, 17*(1), 58–73. https://doi.org/10.14198/jhse.2022.171.07.

Yunus, M., Raharjo, S., Suwanto, W., Pelana, R., & Giang, N. T. (2024). The effect of high-intensity circuit training on physical fitness in healthy young males. *Retos, 54*, 243–247. https://doi.org/10.47197/retos.v54.102904.

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