

***Integrasi Edukasi Kesehatan, Skrining Postur, dan Latihan Plyometrik
untuk Meningkatkan Kebugaran Fisik Remaja***

**Integrating Health Education, Postural Screening, and Plyometric Exercise
to Improve Adolescent Physical Fitness**

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Abstract

This community service program addressed increasing adolescent health issues, including poor posture habits, low physical activity participation, and declining physical fitness. The program aimed to prevent postural disorders and improve physical fitness among students at SMA Negeri 21 Makassar through health education, posture and fitness screening, and plyometric exercise training. Eighty-seven students participated in educational sessions on the importance of physical activity and proper posture, screening of anthropometric characteristics, handgrip strength, dynamic balance, and postural alignment, and 37 students participated in plyometric exercises. Screening data were analyzed descriptively. The data showed that most students had body weight predominantly ranging from 40.1–50 kg and height from 151–160 cm, 19 students demonstrated lower grip strength, and the Y Balance Test indicated good dynamic balance ability, with left–right differences below 10%, suggesting a low risk of injury. Mild postural deviations, including forward head posture and rounded shoulders, were identified in several students. The study generated baseline data regarding students' posture and fitness conditions, which could support future physical education programs. This study also provided health education and independent plyometric exercise training for students. This activity contributed to the strengthened promotive and preventive collaboration among physiotherapists, teachers, and schools in supporting adolescent physical health.

Keywords: physical fitness, plyometric exercise, posture screening

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Abstrak

Program pengabdian kepada masyarakat ini dilaksanakan sebagai respons terhadap meningkatnya permasalahan kesehatan pada remaja, termasuk kebiasaan postur tubuh yang kurang baik, rendahnya partisipasi dalam aktivitas fisik, serta menurunnya tingkat kebugaran jasmani. Program ini bertujuan untuk mencegah gangguan postur dan meningkatkan kebugaran fisik siswa di SMA Negeri 21 Makassar melalui edukasi kesehatan, skrining postur dan kebugaran, serta pelatihan plyometrik. Sebanyak 87 siswa berpartisipasi dalam sesi edukasi mengenai pentingnya aktivitas fisik dan postur tubuh yang benar, skrining karakteristik antropometri, kekuatan genggam tangan (*handgrip strength*), keseimbangan dinamis, dan keselarasan postur. Selain itu, sebanyak 37 siswa mengikuti program latihan pliometrik. Data hasil skrining dianalisis secara deskriptif. Hasil menunjukkan bahwa sebagian besar siswa memiliki berat badan pada rentang 40,1–50 kg dan tinggi badan pada rentang 151–160 cm. Sebanyak 19 siswa menunjukkan kekuatan genggam yang rendah. Hasil *Y Balance Test* menunjukkan kemampuan keseimbangan dinamis yang baik, dengan perbedaan sisi kiri dan kanan kurang dari 10%, yang mengindikasikan risiko cedera yang rendah. Beberapa siswa juga ditemukan mengalami deviasi postur ringan, seperti *forward head posture* (postur kepala maju) dan *rounded shoulders* (bahu membulat). Kegiatan ini menghasilkan data dasar mengenai kondisi postur dan kebugaran siswa yang dapat digunakan sebagai dasar pengembangan program pendidikan jasmani di masa mendatang. Selain itu, kegiatan ini juga memberikan edukasi kesehatan dan pelatihan latihan plyometrik mandiri kepada siswa. Program ini berkontribusi dalam memperkuat kolaborasi promotif dan preventif antara fisioterapis, guru, dan pihak sekolah dalam mendukung kesehatan fisik remaja.

Kata Kunci: kebugaran fisik, latihan plyometrik, skrining postur

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Highlight:

- The program aims to prevent postural disorders and improve physical fitness in adolescents, engaging 87 students from SMA Negeri 21 Makassar in educational and screening sessions, with 37 of them participating in plyometric training.
- The initiative successfully established baseline data on the students' physical condition and identified mild postural deviations in several students, such as forward head posture and rounded shoulders.
- The program successfully equipped students with independent plyometric training skills while strengthening promotive and preventive collaboration among physiotherapists, teachers, and school authorities to maintain adolescent health.

INTRODUCTION

Adolescent growth represents a critical phase in physical development, during which the body undergoes rapid changes in height, muscle mass, and the skeletal structure. Adequate physical activity and proper posture are essential to support optimal growth and prevent future musculoskeletal health problems. However, many adolescents experience poor posture, insufficient physical activity, and a lack of awareness regarding the importance of exercise and postural maintenance.

Poor posture among adolescents may result from prolonged gadget use, intensive online learning, limited outdoor activity, and inadequate intake of vitamin D and C (Mei *et al.*, 2025). Moreover, carrying school bags that exceed the recommended weight proportion relative to body mass increases the risk of chronic back pain, particularly during the growth spurt phase of puberty (Ahmed *et al.*, 2024). Persistent poor posture can lead to structural changes in the spine, such as scoliosis, lordosis, or kyphosis, accompanied by muscular imbalance, reduced flexibility, and impaired joint mobility (Brzęk *et al.*, 2017).

In addition to postural problems, sedentary behavior and lack of physical activity have become major issues among adolescents. The advancement of digital technology has encouraged children and adolescents to spend excessive time in front of screens, leading to a drastic reduction in their daily physical activity. Global studies have reported that more than 80% of adolescents fail to meet the WHO recommendation of engaging in at least 60 minutes of daily physical activity (Guthold *et al.*, 2020). This condition is associated with decreased cardiorespiratory fitness, increased risk of obesity and metabolic disorders, and psychosocial problems such as anxiety and depression (Chaput *et al.*, 2020). These factors are closely interconnected, as poor posture is often associated with sedentary behavior and reduced physical activity levels, which together may contribute to declining physical fitness and adversely affect adolescents' musculoskeletal health.

Physical exercise interventions are crucial for addressing these issues. Plyometric exercise is an effective type of exercise for improving adolescent fitness. Several studies have demonstrated that plyometric training enhances muscle strength, explosive speed, and motor coordination in children and adolescents. A study found that after 12 weeks of plyometric training, adolescents showed significant improvements in both speed and explosive strength (Kryeziu *et al.*, 2023). Syahrul *et al.* (2024) also revealed the positive effects of plyometric exercise conducted three times a week for six months, including significant increases in height among adolescents, improved VO₂ Max in female adolescents, and enhanced bone mineral density and bone mineral content in males (Syahrul *et al.*, 2024). Furthermore, systematic reviews and meta-analyses have confirmed that plyometric jump training effectively improves muscle strength, sprint performance, horizontal and vertical jump ability, and the reactive strength index in adolescent populations (Ramirez-Campillo *et al.*, 2023).

Postural screening and education are equally important. Poor sitting posture caused by prolonged gadget use or unsuitable school environments has been linked to various musculoskeletal abnormalities, including hyperkyphosis, forward head posture, and pelvic malalignment. A cross-sectional study involving 240 students found that improper sitting posture was associated with spinal alterations, such as anterior head posture and pelvic retroversion (Araújo *et al.*, 2022). Postural education programs have been shown to effectively improve ergonomic knowledge and postural practices among adolescents. One study demonstrated that a single 90-minute school physiotherapy

session significantly enhanced students' theoretical and practical test scores on posture and improved postural habits (Minghelli, 2022). Moreover, a one-year back-school and postural education program for students aged 10–16 years significantly increased postural literacy and reduced the incidence of low back pain (Minghelli et al., 2021).

A comprehensive approach that combines education, screening, and exercise is warranted, as education promotes awareness and behavioral change, screening enables early identification of postural and fitness-related issues while generating baseline health data, and exercise provides students with practical self-management strategies to support long-term musculoskeletal health. This program was conducted at SMA Negeri 21 Makassar as a preventive effort against musculoskeletal health problems and to promote a school environment that supports optimal physical growth in adolescents.

METHOD

A total of 87 students were selected as participants based on the following inclusion criteria: aged 15–17 years, no history of musculoskeletal injury within the last three months, and willingness to participate in postural screening, health education, and plyometric training. The exclusion criteria included serious medical conditions (neurological or cardiovascular disorders). Based on the screening results, students identified as requiring improvement in physical fitness were invited to participate in a plyometric exercise program.

The activity was carried out sequentially through three stages: health education, postural and physical fitness screening, and plyometric exercise training. All participants first attended the educational session before proceeding to the screening activities. Based on the screening results and participant availability, a subgroup of students subsequently participated in the plyometric exercise session.

Health education

The health education session was attended by 87 eleventh-grade students from SMA Negeri 21 Makassar. The session lasted approximately 60 minutes and was delivered by physiotherapy lecturers. The educational materials covered the importance of physical activity and its benefits for promoting physical development during adolescence, as well as guidelines for maintaining a proper posture during daily activities. The purpose of this session was to increase students' awareness and understanding of the relationship between their posture, physical fitness, and overall health.

Postural and physical fitness screening

Immediately after the education session, students underwent postural and physical fitness screening at designated assessment stations within the school environment. The screening process was supervised by physiotherapy lecturers and conducted by trained physiotherapy students. Each participant completed the assessments within approximately 15–20 minutes.

The screening process included anthropometric measurements, postural assessment, and physical fitness evaluation, aimed at describing the students' initial physical condition. The screening used the following instruments: 1) Anthropometric measurements of body height and weight were performed using a digital scale and microtoise; 2) Postural examination using MB (Markus Bader), a camera, and a tripod; 3) Physical fitness assessment consisted of flexibility measured by the sit-and-reach test,

balance measured by the Y Balance Test (YBT), and muscle strength measured using a handgrip dynamometer.

Plyometric exercise

Following the screening process, 37 students participated in a supervised plyometric exercise session conducted on the school sports field. The exercise program was led by physiotherapy lecturers and assisted by physiotherapy students. The total duration of the session was approximately 40 minutes and consisted of three sequential phases: 1) The warm-up aimed to prevent injury during exercise, maximize performance during the main exercise, and make the training session more productive. The duration was 10 min; 2) The main exercise lasted 20 minutes; 3) The cool-down aimed to help the body relax, improve blood circulation, and normalize breathing frequency. The duration was 10 min.

After the activity was completed, the screening data were analyzed descriptively to describe the participants' conditions. The analysis was carried out through the presentation of frequency distribution, percentage, mean, and standard deviation to obtain a general overview of the students' posture and fitness status. The results of this analysis served as the basis for identifying potential risks of postural disorders and aspects of fitness that need improvement. This information was also useful for the school as a reference in monitoring students' physical conditions and planning more targeted physical activity programs.

Through this activity, it was expected that students would have a better understanding of the importance of physical activity and posture maintenance for overall physical development. In addition, students were expected to be able to practice plyometric exercises independently at home or in their surroundings in an enjoyable way. Thus, they could shift from a sedentary lifestyle to an active one, which in the long term could support optimal height growth through the regular implementation of a home plyometric exercise program.

RESULTS AND DISCUSSION

This activity consisted of three activities, namely health education, postural and physical fitness screening, and plyometric exercise. The first stage was a health education session that discussed the importance of physical activity for adolescent growth and development, as well as the maintenance of good posture.



Figure 1. Implementation of health education. A and B. Education on the importance of physical activity for health and physical fitness. C. Education on maintaining proper posture in daily activities. D. Demonstration of simple exercises aimed at improving and maintaining optimal body posture

After the health education session was completed, the activity continued with a health screening. This screening included anthropometric measurements of body height and weight, postural assessment to identify the presence of abnormalities or poor postural habits, and physical fitness evaluation consisting of flexibility, balance, and muscle strength tests to assess the participants' physical ability levels (Figure 2). Through this activity, participants not only gained theoretical understanding of the importance of physical activity and good posture but also obtained a real overview of their own physical condition as a basis for improvement and enhancement of fitness in the future.



Figure 2. Health screening activities. A. Measurement of height using a microtoise. B. Measurement of body weight using a digital scale. C. Postural assessment using MB Ruler, camera, and tripod. D. Balance assessment using the Y Balance Test. E. Flexibility assessment using the Sit and Reach Test

Based on the results of the anthropometric screening (Table 1), it was found that the majority of students had a body weight of 40.1–50 kg (33 students), of whom 24 were female. In addition, two male students had a body weight above 100 kg, while nine students had a body weight of 30–40 kg, consisting of six females and three males.

Regarding height, the majority of students (45 students) had a height of 151–160 cm, with 34 of them being female. The anthropometric measurements also showed that among female students, 11 had a height of 140–150 cm, and nine had a body weight of 30–40 kg (six females and three males). These findings indicate that, in general, the students' height and weight remain predominantly ranging from 40.1–50 kg and height from 151–160 cm, although some variations were observed between sexes. Such differences are understandable since the rate of physical growth differs between males and females. Females typically experience a growth spurt earlier, whereas males reach their peak growth a few years later (Zhao et al., 2023).

Table 1. Results of anthropometric measurements based on age and sex

Variable		Age			Total	%	Sex		Total	%
		(Years)					Male	Female		
		15	16	17						
Weight (Kg)	30-40	0	9	0	9	10.3	3	6	9	10.3
	40.1-50	3	28	2	33	37.9	9	24	33	37.9
	50.1-60	2	16	0	18	20.7	8	10	18	20.5
	60.1-70	2	13	0	15	17.2	9	6	15	17.2
	70.1-80	0	5	0	5	5.8	4	1	5	5.8
	80.1-90	0	3	0	3	3.5	2	1	3	3.5
	90.1-100	0	1	1	2	2.3	2	0	2	2.3
	>100	0	2	0	2	2.3	2	0	2	2.3
Height (cm)	140-150	1	10	0	11	12.6	0	11	11	12.6
	151-160	4	39	2	45	51.8	11	34	45	51.8
	161-170	2	18	1	21	24.1	18	3	21	24.1
	171-180	0	10	0	10	11.5	10	0	10	11.5
Total		7	77	3	87	100	39	48	87	100

Source: Primary data, 2025

The group of students with a body weight of 30–40 kg (six females and three males) may indicate lower nutritional status or suboptimal body mass, particularly when compared to the standard height-for-age reference and the expected development of fat-free mass during puberty. Previous studies have shown that among children and adolescents, lean body mass tends to be higher in males after puberty, whereas body fat percentage increases more rapidly in females during adolescence (Zhao et al., 2023). Meanwhile, among male students with a height of 171–180 cm, it appears that some are undergoing a rapid growth phase, which is characteristic of early to mid-puberty, marked by an increase in bone length and skeletal muscle mass (Toselli et al., 2022).

Overall, these findings emphasize that although most students fall within a normal anthropometric range, there exists a subgroup with lower body weight that may require special attention in terms of nutrition, physical activity, and neuromuscular development. Given the positive association between healthy body composition and levels of physical fitness and muscle strength in adolescents, structured physical activity, light-to-moderate resistance exercises, and regular nutritional monitoring are highly recommended for students with lower body weight.

Table 2 shows that the majority of participants had handgrip strength within the normal category (49 students), with 42 of them aged 16 years. In addition, there were 19 students aged 16 years with low handgrip strength, 12 of whom were male. This finding is notable, as physiologically, males generally possess greater muscle mass and higher grip strength compared to females of the same age. This condition may indicate a potential decline in muscular fitness among adolescent males, particularly in the upper-extremity muscles that play a crucial role in gripping activities.

However, handgrip strength does not solely reflect the capacity of the hand and forearm muscles, it also represents the overall condition of the musculoskeletal system (Yusfina et al., 2025). Therefore, these results emphasize the importance of regular physical activity in supporting muscle strength development during adolescence.

Table 2. Overview of handgrip strength among students of SMA Negeri 21 Makassar based on age and sex

Variable		Mean±SD	Handgrip Strength			Total
			Low	Normal	High	
Age (Years)	15	27.95 ± 6.94	0	6	0	6
	16	28.20 ± 8.52	19	42	2	63
	17	39.39	0	1	0	1
Sex	Male	34.04 ± 6.25	12	24	0	36
	Female	22.27 ± 5.72	7	25	2	34
Total			19	49	2	70

Source: Primary data, 2025

Table 3 presents the results of the body flexibility assessment using the Sit and Reach Test conducted on 70 adolescent students aged 15-17 years. A total of 38 students demonstrated high flexibility, predominantly among the 16-year-old group. The proportion of participants with high flexibility was greater among males (33 students) than among females (5 students).

Table 3. Flexibility assessment using the sit and reach test

Variable		Mean±SD	Flexibility Score			Total
			Low	Normal	High	
Age (Years)	15	33.14 ± 10.37	1	2	3	6
	16	34.83 ± 9.97	11	18	34	63
	17	40 ± 0.00	0	0	1	1
Sex	Male	34.61 ± 10.00	1	2	33	36
	Female	34.98 ± 9.84	11	18	5	34
Total			12	20	38	70

Source: Primary data, 2025

However, 11 female students showed low flexibility. Several factors may have contributed to this finding. Low levels of physical activity can lead to reduced muscle and connective tissue elasticity in the joints. Adolescent females generally participate less in sports or dynamic activities, such as stretching exercises, gymnastics, and athletic games, than males. Regular stretching exercises are known to enhance the joint range of motion and optimize neuromuscular function, whereas a sedentary lifestyle accelerates the decline in tissue elasticity.

In addition, hormonal changes during puberty can influence tissue stiffness and neuromuscular function. Fluctuations in estrogen and progesterone levels among adolescent females may cause increased fluid retention and changes in the viscoelastic properties of the muscles and tendons, which can affect flexibility performance. Therefore, the lower flexibility observed in some female students in this study was likely influenced by a combination of physiological, hormonal, and behavioral factors related to suboptimal physical activity.

Based on the results of the Y Balance Test (YBT) conducted on 54 adolescents aged 15–17 years (23 males and 31 females), data on dynamic balance were obtained, as shown in Table 4. The average left-side YBT score among males was 85.68 ± 10.67 , while among females it was 90.36 ± 13.67 . For the right-sided score, males had an average of 85.35 ± 11.13 , whereas females scored 90.76 ± 12.75 .

Table 4. Balance assessment using the Y Balance Test (YBT)

Variable	Sex	N	Min	Max	Mean±SD	% Difference
YBT Left	Male	23	63	105	85.68±10.67	5.65*
	Female	31	64	126	90.36±13.67	5.36**
YBT Right	Male	23	61	107	85.35±11.13	
	Female	31	69	128	90.76±12.75	
Total		54				

* Percentage Difference in Left–Right YBT Scores Among Male Students

**Percentage Difference in Left–Right YBT Scores Among Female Students

Source: Primary data, 2025

When compared with the YBT composite score threshold of 85%, which categorizes individuals as balanced ($\geq 85\%$) or unbalanced ($< 85\%$), the results indicated that the mean values for both male and female participants fell within the balanced category. This finding reflects good dynamic balance ability in both groups.

In addition, the percentage difference between the left and right sides was relatively small (5.65% in males and 5.36% in females), indicating a high degree of bilateral symmetry in dynamic balance performance. Previous studies have suggested that greater inter-limb asymmetry in the Y-Balance Test may be associated with impaired neuromuscular control and an increased risk of lower-extremity injury, whereas smaller side-to-side differences generally reflect more symmetrical postural control (Plisky et al., 2021). Therefore, the present findings indicate that both male and female adolescents demonstrated symmetrical and stable dynamic balance, with no meaningful lateral dominance between the right and left limbs.

Table 5. Postural assessment

Variable		Forward Head Posture Test		Total	Rounded Shoulder Posture Test		Total
		Normal (%)	Forward Head Posture (%)		Normal (%)	Rounded Shoulder (%)	
Age (Years)	15	2 (7.14)	0 (0)	2	2 (7.14)	0 (0)	2
	16	18 (64.29)	7 (25)	25	19 (67.86)	6 (21.43)	25
	17	0 (0)	1 (3.57)	1	1 (3.57)	0 (0)	1
Total		20 (71.43)	8 (28.57)	28	22 (78.57)	6 (21.43)	28

Source: Primary data, 2025

The postural assessment (Table 5) focused on identifying forward head posture and rounded shoulder posture, specifically among male students. The results showed that the majority of students (71.43%) exhibited normal head posture, while eight students (28.57%) demonstrated postural deviations, seven of whom were 16 years old. In addition, examination of rounded shoulder posture revealed that six students showed indications of postural abnormalities, all of whom were also aged 16 years.

Overall, most students displayed normal postures, while a small proportion exhibited mild deviations in the head and shoulder regions. The average measurement values remained within the normal range, indicating that the general postural patterns

among this group of adolescents were good. However, the presence of several postural deviations warrants attention, as habits such as prolonged use of gadgets and static sitting positions have been reported as major risk factors for postural deviations during adolescence.

Therefore, these findings highlight the importance of early educational interventions aimed at correcting improper postural habits to prevent the development of musculoskeletal disorders in adulthood.

Of all the participants who underwent health screening, 37 students met the criteria to participate in the plyometric exercise session (Figure 3). The training was conducted in an open field for a total duration of 40 minutes, consisting of 10 min of warm-up, 20 min of main exercises, and 10 minutes of cool-down. During the activity, the students received direct guidance on proper plyometric techniques and movement forms to prevent injury and maximize the benefits of the exercise.

In addition to the field sessions, students were provided with education and demonstrations on how to perform plyometric exercises independently at school and at home, enabling them to continue the exercises regularly as part of an active lifestyle. This approach is expected to enhance muscle strength, agility, and overall physical fitness while fostering awareness of the importance of regular physical activity in daily life.



Figure 3. Group-based plyometric exercises conducted with female students of SMAN 21 Makassar

The implementation of plyometric training within the school environment in this study also has significant educational value. An education-based physiotherapy approach enables students to understand the relationship between physical activity, muscle strength, and proper body posture. Such education is essential for developing healthy lifestyle behaviors and musculoskeletal health awareness from an early age.

Providing strength and stability exercises during adolescence is important for injury prevention, postural development, and enhancing self-confidence in physical activities. Therefore, the combination of screening and plyometric training can be viewed as a tangible form of preventive physiotherapy intervention in educational settings.

In terms of benefits, this activity had two major impacts. First, from a clinical perspective, the screening and exercise sessions helped identify and correct mild musculoskeletal disorders before they progressed. Second, from an educational

standpoint, the program fostered students' understanding of the importance of physical activity and proper posture, potentially cultivating a movement-conscious culture within the school.

However, this activity also had certain limitations, including the absence of follow-up evaluations to determine the long-term effects of plyometric training on postural and balance improvement, as well as the lack of control over external factors, such as students' physical activity levels outside the school setting.

CONCLUSION

The health education, postural and physical fitness screening, and plyometric exercise program conducted at SMAN 21 Makassar demonstrated both educational and clinical benefits for the participants. Health education improved students' awareness of the importance of physical activity, proper posture, and healthy lifestyle behaviors, while the screening activities provided baseline information on students' anthropometric characteristics, postural alignment, muscle strength, flexibility, and balance. In addition, the plyometric exercise training equipped students with practical skills to engage in regular physical activity independently. Overall, the program contributed to the promotion of adolescent musculoskeletal health through an integrated approach combining education, screening, and exercise training. This initiative underscores the significance of implementing preventive physiotherapy interventions in the school environment to support optimal physical development in adolescents. Future programs should include long-term evaluations to assess the sustained effects of plyometric training on posture, muscle strength, and balance, as well as control for external factors such as students' physical activity levels outside of school.

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BIBLIOGRAPHY

- Ahmed, N.A., Ahmed, M.M., Ahmed, N.A., Shahid, A., Mittal, G., 2024. Schoolchildren's Musculoskeletal Pain and Backpack Weight Impact on Posture: A Short-Term Study. *Journal of Pharmacy and Bioallied Sciences* 16(3), S2497–S2499. https://doi.org/10.4103/jpbs.jpbs_339_24
- Araújo, L.G.L., Rodrigues, V.P., Figueiredo, I.A., Medeiros, M.N.L., 2022. Association between Sitting Posture on School Furniture and Spinal Changes in Adolescents. *International Journal of Adolescent Medicine and Health* 34(6), 469–475. <https://doi.org/10.1515/ijamh-2020-0179>
- Brzęk, A., Dworrak, T., Strauss, M., Sanchis-Gomar, F., Sabbah, I., Dworrak, B., Leischik, R., 2017. The Weight of Pupils' Schoolbags in Early School Age and its Influence on Body Posture. *BMC Musculoskeletal Disorders* 18(117), 1-11.

- <https://doi.org/10.1186/s12891-017-1462-z>
- Chaput, J.P., Willumsen, J., Bull, F., Chou, R., Ekelund, U., Firth, J., Jago, R., Ortega, F.B., Katzmarzyk, P.T., 2020. 2020 WHO Guidelines on Physical Activity and Sedentary Behaviour for Children and Adolescents Aged 5–17 Years: Summary of the Evidence. *International Journal of Behavioral Nutrition and Physical Activity* 17(141), 1-9. <https://doi.org/10.1186/s12966-020-01037-z>
- Guthold, R., Stevens, G.A., Riley, L.M., Bull, F.C., 2020. Global Trends in Insufficient Physical Activity Among Adolescents: A Pooled Analysis of 298 Population-Based Surveys with 1.6 million Participants. *The Lancet Child & Adolescent Health* 4(1), 23–35. [https://doi.org/10.1016/S2352-4642\(19\)30323-2](https://doi.org/10.1016/S2352-4642(19)30323-2)
- Kryeziu, A.R., Iseni, A., Teodor, D.F., Croitoru, H., Badau, D., 2023. Effect of 12 Weeks of the Plyometric Training Program Model on Speed and Explosive Strength Abilities in Adolescents. *Applied Sciences* 13(5), 1-18. <https://doi.org/10.3390/app13052776>
- Mei, Y., Lin, Y.F., Gong, Z., Yan, B., Liang, Q., 2025. Prevalence of Incorrect Posture among School Adolescents After the COVID-19 Pandemic: A Large Population-Based Scoliosis Screening in China. *Journal of Orthopaedic Surgery and Research* 20(156), 1-12. <https://doi.org/10.1186/s13018-025-05479-8>
- Minghelli, B., 2022. Postural Habits in Adolescents: The Influence of A School Physiotherapy Program on Improving the Knowledge of Postures. *International Journal of Adolescent Medicine and Health* 34(3), 1-22. <https://doi.org/10.1515/ijamh-2019-0138>
- Minghelli, B., Nunes, C., Oliveira, R., 2021. Effectiveness of a Back School and Postural Education Program on the Improvement of Literacy About Postures and Low Back Pain in Adolescents: A 1-Year Follow-Up Study. *Journal of Orthopaedic Science* 26(4), 543–547. <https://doi.org/10.1016/j.jos.2020.05.014>
- Plisky, P., Schwartkopf-Phifer, K., Huebner, B., Garner, M.B., Bullock, G., 2021. Systematic Review and Meta-Analysis of the Y-Balance Test Lower Quarter: Reliability, Discriminant Validity, and Predictive Validity. *International Journal of Sports Physical Therapy* 16(5), 1190–1209. <https://pubmed.ncbi.nlm.nih.gov/34631241/>
- Ramirez-Campillo, R., Sortwell, A., Moran, J., Afonso, J., Clemente, F.M., Lloyd, R. S., Oliver, J.L., Pedley, J., Granacher, U., 2023. Plyometric-Jump Training Effects on Physical Fitness and Sport-Specific Performance According to Maturity: A Systematic Review with Meta-analysis. *Sports Medicine Open* 9(23), 1-23. <https://doi.org/10.1186/s40798-023-00568-6>
- Syahrul, S., Rijal, R., Hardianto, Y., Rabia, R., 2024. The Effect of Plyometric Exercise on Bone Mineralisation and Physical Fitness in Adolescents. *Physiotherapy Quarterly* 32(4), 11–18. <https://doi.org/10.5114/pq/171963>
- Toselli, S., Mauro, M., Grigoletto, A., Cataldi, S., Benedetti, L., Nanni, G., Di Miceli, R., Aiello, P., Gallamini, D., Fischetti, F., Greco, G., 2022. Assessment of Body Composition and Physical Performance of Young Soccer Players: Differences According to the Competitive Level. *Biology* 11(6), 1-16. <https://doi.org/10.3390/biology11060823>
- Yusfina, Y., Hafid, A.B.A., Muthiah, M., 2025. Kekuatan Genggaman Tangan dan Fungsi Kognitif sebagai Indikator Klinis terhadap Kemandirian Aktivitas Instrumental Sehari-hari. *Jurnal Fisioterapi dan Rehabilitasi* 9(2), 269–279.
- Zhao, Y., Gong, J., Ji, Y., Zhao, X., He, L., Cai, S., Yan, X., 2023. Cross-Sectional Study of Characteristics of Body Composition of 24,845 Children and

Adolescents Aged 3–17 Years in Suzhou. *BMC Pediatrics* 23(358), 1-10.
<https://doi.org/10.1186/s12887-023-04134-7>