Effects of different swimming styles on postural assessment in mid-level young swimmers

Vincenzo Cristian Francavilla,[1] Maria Chiara Parisi,[1] Maria Pia Muzzicato,[2] Omar Mingrino,[2] Antonino Zoffoli,[3] Marinella Coco,[4] Donatella Di Corrado[2]

[1]Department of Medicine and Surgery, Kore University, Enna, Italy; [2]Department of Sport Sciences, Kore University, Enna, Italy; [3]Department of Research, Italian Center Studies of Osteopathy, Catania, Italy; [4]Department of Education Sciences, University of Catania, Italy.

Abstract

It is well-known that swimming purposes to increase the tonic-postural control. Beyond its physiological advantages, swimming also offers an exclusive platform to explore the complex interplay between body biomechanics and posture. The specific aim of this study was to investigate the effects of main swimming styles on postural balance in young athletes. Forty-one participants, aged between 11 and 15 years old (M=13, SD=1.47), were recruited. The training schedule usually consisted of 2/3 h (2.4±0.46) per day (five to six weekly workouts). Measures included a postural assessment to identify the presence of postural deficits and a baropodometric stabilometry to evaluate the center of pressure. Measurements were performed before T0 (baseline), after 6 months (T1), and at the end, after 12 months (T2). Beforehand, all participants undertook identification of the swimming style and pain intensity level. Results showed that Breaststroke and Butterfly athletes had clear improvements in postural balance compared to Backstroke and Freestyle athletes. In conclusion, our results suggest that a detailed knowledge of the different swimming styles plays a significant role in improving balance and postural stability in young athletes, highlighting the fundamental role of the kinesiology in sports traumatology.

Key Words: posture; swimming; stability; pain.

Eur J Transl Myol 35 (1) 13150, 2025 doi: 10.4081/ejtm.2024.13150

Swimming is a sport that allows the body to move and float in water. It is a cyclical sport as it includes a series of arm and leg movements with elevated coordination value. Fundamental elements of swimming from a technical point of view can be summarized as: body position in the water, stroke, kicking, breathing, coordination and synchronization.[1]

The movements of specific body parts during swimming have been recognized in the procedure of four swimming styles: i) freestyle is one of the first strokes learnt by young swimmers. To perform it, lie on tummy in the water, by alternating arms forward, whereas legs should be kicking in a flutter movement; ii) butterfly is the hardest stroke, but offers an excellent workout. Start on stomach facing the bottom of the pool, taking arms overhead. Legs should be straight; iii) backstroke is the same set of movements of Freestyle, but on back; arms will windmill away from body to propel the swimmer backwards while they are under the water. Legs should be kicking in a flutter movement; iv) breaststroke is the slowest stroke; start with tummy facing down in water, moving arms in a half-circle in front of body. Your legs should perform a whip kick.[2] As is known, different muscles are used for different strokes, so learning all of the strokes provides a more complete workout. The advantages of swimming are more reflected in the improvement of the internal function of the human body.[3] The ability of athletes to absorb oxygen is also improved through the stimulation of deep breathing, because the water density in the swimming pool is large, the respiratory muscles of swimmers' travel in the water, due to the pressure from the water. The swimmer's abdominal cavity and chest are under more pressure than usual, which makes the respiratory muscles exercise. So as to additional improve their own vital capacity.[4] Exercises that stretch the spine in a water environment are effective adequate to treat some anomalies and postural disorders, despite these potential benefits, the relationship between swimming and posture remains intricate and multifaceted.[5,6] There are also known methods of correcting unilateral human scoliosis using the sidestroke swimming technique.[7] Despite the fact that in certain studies and literature we may find results that speak of changes in the backbone in athletes of different sports that include large rotations, it has not yet been determined that these activities lead to a direct acceleration or worsening of postural disorders.[8] The problem that athletes face today is finding a balance between sport practiced and postural deformity. Balance is commonly considered as the ability to maintain an upright position in a particular spatial orientation or to recuperate equilibrium after external dynamic oscillations, and it is in relation with the inertial forces acting on the body and the inertial structures of its segments.[9] At this regard, balance is a decisive component of normal daily activities (e.g., walking, running, and climbing stairs), and in the prevention of falls and resulting injury. Additionally, effective postural balance is considered a good criterion for improving the control of movements in sports and, consequently, for enhancing performance.[10] It can be assessed using several tests in sport and clinical practice. The most reliable method is the recording of Center Of Pressure (CoP) movements during quiet standing. Posture, defined as the alignment and positioning of body parts in relation to one another and to the surrounding environment, is an essential aspect of human movement and health. Postural disorders have been linked to a series of different kinds of pain and dysfunction and, together with spinal deformities, are among the most common diseases in the period of childhood and adolescence.[11] Pain symptoms are among the most common complaints in swimming and are diverse in terms of severity and duration. Early diagnosis can be achieved through screening system and a periodic monitoring of the stand is an inherent requirement to timely detection of deviations. Conservative treatment can prevent the development of severe deformity and avoid surgery. Serious problem of the posture in children and adolescents due to the fact that there is no immediate correction of static deformation, considered as a predisposing factor for the development of structural changes in the spine and diseases of the internal organs.[12] Therefore, bad posture is not insignificant aesthetic drawback that disappears by time. This is a serious health disorder, which often leads to a permanent reduction of capability in career, sport and in life. In the sport field, the majority of studies has focused the effect of swimming on body posture, examining both professional athletes and amateur practitioners.[13-15] Other researches highlight the influence of different sports on the athletes' postures among adolescents.[16,17] However, despite the progress made, there are still many questions to be explored regarding the precise mechanisms through which swimming affects posture and how it can be used therapeutically to correct any postural dysfunctions. Based on these arguments, and given the limited research, the purpose of the study was to investigate the effects of main swimming styles on postural balance in young expert athletes. We hypothesized that the specific swimming style would show potential effects on outcomes of postural balance and also that it may be related to the prevalence and locations of musculoskeletal pain.

Materials and Methods

The research was conducted with forty-one volunteers' young swimmers (21 females and 20 males), ranging from 11 to 15 years (M_{age}=13; *SD*=1.47), were recruited. The inclusion criteria were as follows: absence of motor or neurological deficits, no trauma, no orthopedic injury, or vestibular damage. The exclusion criteria were those currently participating in a balance exercise protocol. The athletes were all members of sports clubs and had a minimum of 4 years of practice experience in the sport at an intermediate level. The training schedule usually consisted of 2/3 h (2.4±0.46) per day (five to six weekly workouts). The procedures were conducted according to the ethical principles stated in the Declaration of Helsinki and were performed with university ethics approval. The study design was approved by the Departmental Research Committee (approval number: UKE-IRBPSY-23.10.03). Before the beginning of the study, each participant received a full explanation of the study procedures and a consent form was signed by their parents. Confidentiality of the responses was also assured. Measurements were conducted individually, in a same laboratory with analogous conditions (room temperature 21°C, electric illumination, and time of day) by a same trained professional. Height and body weight measurements were performed with the athlete in a standing position, barefoot, and wearing comfortable clothing. Height was measured using a digital stationary stadiometer (seca 264, Seca, Birmingham, UK). Body weight was evaluated using a body composition analyzer (seca mBCA 515, Seca, Birmingham, UK). All participants were submitted to a postural assessment to identify the presence of postural deficits and baropodometric stabilometry to evaluate the centre of pressure. Through a postural analysis observation of static posture for alignment and, visual and palpable valuation of paired anatomic landmarks for symmetry, postural deviations, imbalances, muscle weaknesses can be identified. A postural misalignment may designate problems such as scoliosis, postural decompensation, or segmental somatic dysfunctions where asymmetry is observed. Measurements were performed before T0 (baseline - early pre-season period), after 6 months (T1 – mid-season), and at the end, after 12 months (T2 - main competitive period). Beforehand, all participants undertook identification of the swimming style and pain level intensity. Participants were assigned to four groups: 12 Breaststroke, 9 Butterfly, 11 Freestyle and 9 Backstroke.

Baropodometric platform

Postural balance was measured using the FreeMed® baropodometric platform and FreeStep® software 2.0 (Sensor Medica®; Guidonia Montecelio, 00012 Rome, Italy), with the following specific features: platform's surface 440 × 620 mm, with an active surface of 400 × 400 mm and 8-

mm thickness. The participants were placed bipedally, with their bare feet side-by-side on the platform, each foot about 20 cm away from the other, without any type of other support. All subjects were oriented to maintain an upright and natural position, always looking at a fixed point in front of them for 51.2 seconds with open eyes. The software obtains the centre of pressure (CoP) position considered the point at which the total force acting on an individual's foot or feet is concentrated for maintaining stability. The CoP was analyzed considering the average CoP amplitude in two-dimensional position parameters called Anterior-Posterior (AP) and Medial-Lateral (ML) directions, calculated as the common length of the trajectory of the COP only in the given direction, divided by the number of changes of movement direction. Data were collected and analyzed using the software supplied with the platform, which continuously records the CoP trajectories at a sampling rate of 100 Hz.

Postural assessment

To identify the presence of postural deficits, the postural assessment was carried out on 3 planes (frontal, sagittal and transverse) with the landmarks positioned on the skull, spine, pelvis and malleolus. The athlete was instructed to stand still, with feet shoulder-width apart, face forward, and arms relaxed to the sides. The practitioner should have his or her eyes at the level of the area being evaluated. There was 1m distance between the athlete and the assessing kinesiologist to adequately view the athlete's posture. Examples of the various components that can be included in the postural assessment are: head on neck position; symmetry and roundedness of shoulder; spinal curvature; lumbar spine; symmetry of hips level; etc. A basic musculoskeletal postural assessment is sufficiently reliable when performed by trained clinicians.

Pain assessment

The Numeric Pain Rating Scale (NPRS), a unidimensional self-report measure of pain intensity in adults, was used to rate the intensity of the current pain, where 0 means "no pain" and 10 "worst possible pain".[18] The swimmers were asked to choose a numerical value that best described the subjective assessment of pain intensity experienced at baseline (T0), after 6 months (T1), and after 12 months (T2). Based on previous studies,[19-21] we categorized pain NPRS scores as mild (1–3), moderate (4–6), or severe (7–10). The NPRS is a valid scale to measure pain intensity and it has good test-retest reliability (r=.83–.96) in individuals with chronic pain and musculoskeletal pathology.

Data analysis

Descriptive statistics were used to calculate the mean and standard deviation (SD). One-way Analysis of Variance (ANOVA) was conducted to identify statistically significant differences between the groups in the level of postural balance. An effect size was used for each analysis with the eta-squared statistic (η^2) to evaluate the practical significance of findings. The ranges for the interpretation of the effect size based on eta-squared indicated a small effect (0.01), moderate effect (0.06) and large effect (0.14).[22] All statistical analyses were processed with SPSS version 26 (SPSS Inc., Chicago, IL, USA) and presented as mean±SD (level of significance: $p \leq .05$).

Results

Anthropometric characteristics

Anthropometric characteristics of participants are illustrated in Table 1.

Comparison of postural balance

Center of pressure position in the Medial-Lateral direction (ML) and Anterior-Posterior direction (AP) are shown in Table 2.

Results showed a significant improvement in the Center of pressure position in the Medial-Lateral direction, in Breaststroke and Butterfly groups (respectively p=.02 and p=.001), and in the Center of pressure position in the An-

Table 1. *Participants' anthropometric characteristics. Mean ±standard deviations, (%).*

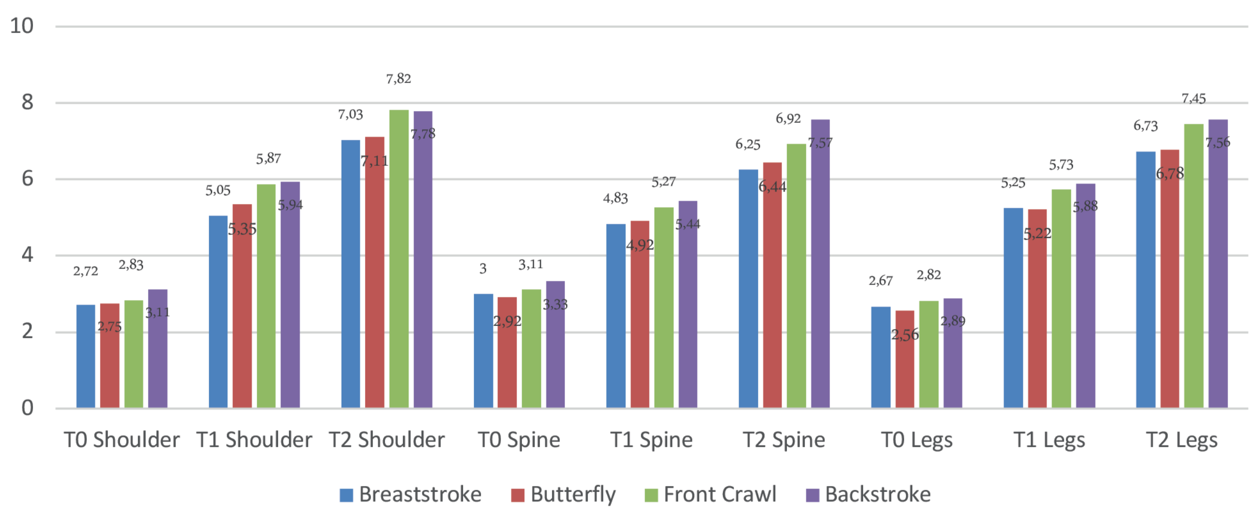
	Age (Years)	Height (m)	Weight (kg)	Gender
Breaststroke (=12)	12.5±1.31	1.67±3.86	81.7±7.29	6 m (50), 6 f (50)
Butterfly (=9)	13.3±1.66	1.70±4.14	91.8±6.32	4 m (44.4), 5 f (55.6)
Freestyle (=11)	13.2±1.54	1.68±3.54	91.8±6.32	6 m (54.5), 5 f (45.5)
Backstroke (=9)	13±1.50	1.69±4.11	77.4±7.37	4 m (44.4), 5 f (55.6)
p	0.781	0.784	0.692	0.613

Statistically, no differences were found between these groups in terms of age, height or weight.
The groups were equally well balanced in terms of gender.

Eur J Transl Myol 35 (1) 13150, 2025 doi: 10.4081/ejtm.2024.13150

terior-Posterior direction, in Breaststroke and Butterfly groups (respectively p=.03 and p=.02), compared with Freestyle and Backstroke groups. Finally, the Effect Size was found to be stronger (η^2 =.13) in the Center of pressure position in the Medial-Lateral direction. Postural assessment showed various musculoskeletal dysfunctions: range of motion, glenohumeral instability, rounded shoulders, scapular dyskinesis, poor posture, and lack of core stability.

Figure 1 shows the subjective assessment of pain intensity experienced at the three assessment times to "Shoulder", "Spine", and "Legs", according to the different swimming styles (Figure 1).
At the beginning of the sports season, corresponding with baseline (T0), the pain level was quite mild (1–3). Subsequently, it is noticeable that the intensity pain increased to become severe (7–10), especially for Freestyle and Backstroke groups.



T_0, baseline; T_1, after 6 weeks; T_2, after 12 weeks.

Figure 1. *Assessment of pain intensity.*

Table 2. *Mean (±SD) for postural balance (Center of Pressure) across session and groups.*

Postural balance		**T_0**	**T_1**	**T_2**	**F**	**η^2**
COP_{ML}	Breaststroke	4.21±3.59	4.39±3.10	4.83±2.24**		
	Butterfly	3.27±2.22	3.57±2.19	3.78±2.03**	22.14	.13
	Freestyle	3.14±2.17	3.15±2.16	3.13±2.08		
	Backstroke	3.18±2.15	3.17±2.27	3.18±2.11		
COP_{AP}	Breaststroke	29.11±10.25	31.12±9.15	33.95±9.05*		
	Butterfly	29.92±11.03	30.81±10.54	32.96±10.01*	29.32	.11
	Freestyle	28.37±11.56	27.19±10.46	28.09±11.16		
	Backstroke	28.59±11.45	28.39±11.58	29.01±11.61		

**p <.05, **p <.01. COP_{ML}, Center of pressure position in the Medial-Lateral direction;*
COP_{AP}, Center of pressure position in the Anterior-Posterior direction;
T_0, baseline; T_1, after 6 weeks; T_2, after 12 weeks.

Discussion

The aquatic environment presents a distinctive challenge and opportunity for posture regulation. Hydrostatic pressure and fluid resistance alter the biomechanical demands placed on the body during swimming, influencing muscle activation patterns, joint angles, and spinal alignment. Postural balance is an essential part of a wide range of activities, from daily living tasks to sports. Poor postural control negatively affects sports performance and the quality of life of athletes.[23] Swimming needs a lot of upper-body strength and repetitive motion. As a result, it causes muscle strains and postural issues if the swimmer is not conscious of the position. The purpose of this study was to investigate the effects of main swimming styles on postural balance in young expert athletes. Our hypothesis has been partially supported by obtained results.

The study showed that Breaststroke and Butterfly styles were associated with a significant improvement in the Center of pressure position compared to Freestyle and Backstroke styles. Results are in line with McLeod,[24] who confirm many swim stroke advantages of Breaststroke and Butterfly styles, as they promote balanced muscle development. In fact, Breaststroke style works multiple different muscle groups (thigh muscles, chest, shoulders, core and upper back muscles) promoting a straight spinal extension. Butterfly, with its simultaneous arm movement and dolphin kick, strengthens the entire back. This swimming style also engages a lot of muscles (the core, back, stomach and arms), improving posture and flexibility. In Freestyle and Backstroke, characterized by alternating movements of the limbs, the torso rotates both around its sagittal and longitudinal axis of the body. For this reason, these techniques share similar characteristics (e.g. almost horizontal body position, extending – bending – extending the elbow, flutter kick, etc.) and predominantly recruit the upper body (*i.e.*, deltoids, latissimus dorsi, trapezius, triceps and biceps muscles).[25] Our findings have not found an improvement in postural stabilization and balance parameters in Freestyle and Backstroke athletes' styles. This was confirmed in some studies showing athletes with higher CoP displacements are more prone to injuries.[26,27] These results are in line with the idea that both of these techniques, rotating the back under force, stressed on the spine and increased low back pain.[28]

Finally, the subjective assessment of pain intensity experienced at the three assessment times showed a linear increase of the intensity pain, especially for Freestyle and Backstroke groups. Specifically, Shoulder is the most reported area of pain. These results are in line with previous reports documenting a high prevalence and incidence of shoulder pain in intermediate swimmers.[29-32] The several and large shoulder revolutions can easily overwork soft tissue structures around the shoulder and lead to continuous pain. The so-called "*swimmers' shoulder*" is a term that has generally been used to describe a syndrome with anterior shoulder pain elicited by repetitive impingement of the rotator cuff under the coracoacromial arch.[33]

There are some limitations of this study: i) the relatively small sample size; ii) the study lasted for 12 months, which means that some athletes were assessed during the early preseason period (low performance), while others were tested during the main competitive period (high performance). Future research directions could be extended towards other swimming styles, other age categories, and other swimming categories (*i.e.*, open water swimming and synchronized swimming). Also, other components (spatio-temporal organization and coordination) could be taken into account, which would provide a much more detailed picture regarding their influences in the process of learning swimming styles. Future studies investigating variables affecting posture could also include medical, psychological and social factors in order to recognize these complex relationships.

Conclusions

Balance is an important factor in many athletic skills. The study highlighted that different swimming styles influence postural balance. With the above investigations, it can be stated that improved postural balance provides health benefits and can become an essential component at all stages of human life.[34] In conclusion, swimming coaches should be aware of different individual adaptations by the swimmers over the plan, and should incorporate a core training program to provide stability and strength.

List of abbreviations

CoP, Centre of pressure
AP, Anterior-Posterior
ML, Medial-Lateral
NPRS, Numeric Pain Rating Scale
BMI, Body mass index

Contributions of authors

Writing original draft: DDC, VCF, MCP; writing revision and editing: DDC, MC, VCF; visualization: MPM, OM, AZ; supervision: VCF, DDC, MCP; project design: DDC, MCP; investigation, VCF, MC; data curation: MCP, AZ, OM. All authors read and approved the final edited manuscript.

Acknowledgments

The authors thank all persons who participated in the study.

Funding

This research received no external funding.

Conflict of interest

The authors declare no conflicts of interest.

Ethics approval

The Ethics Committee of the Departmental Research Committee (approval number: UKE-IRBPSY-23.10.03) approved this study. The study is conformed with the Helsinki Declaration of 1964, as revised in 2013, concerning human and animal rights.

Informed consent

All patients participating in this study signed a written informed consent form for participating in this study.

Patient consent for publication

Written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Corresponding author

Donatella Di Corrado, Department of Sport Sciences, KORE University, Cittadella Universitaria, 94100 Enna, Italy.
Tel.: 39.3472468598, Fax: +39.0935.536993.
ORCID ID: orcid.org/0000-0001-8223-6671
E-mail: donatella.dicorrado@unikore.it

Co authors

Maria Chiara Parisi
ORCID ID: 0000-0001-9934-250X
E-mail: mariachiara.parisi@unikore.it

Omar Mingrino
ORCID ID: 0009-0002-7097-9798
E-mail: omarmingrino@icloud.com

Vincenzo Francavilla
ORCID ID: 0000-0002-7337-392X
E-mail: vincenzo.francavilla@unikore.it

Maria Pia Muzzicato
ORCID ID: 0009-0001-9855-3274
E-mail: mariapia.muzzicato@unikorestudente.it

Antonino Zoffoli
ORCID ID: 0009-0001-4255-4584
E-mail: antonino_zoffoli@hotmail.it

Marinella Coco
ORCID ID: 0000-0002-1797-2717
E-mail: marinella.coco@unict.it

References

1. Grigoriou R, Nikodelis T, Kugiumtzis D, Kollias I. Classification methods can identify external constrains in swimming. J Biomech 2019;82:381-6.
2. Lynn A. Swimming: Technique, training, competition strategy. Crowood, Ramsbury 2014.
3. Ruangthai R, Phoemsapthawee J. Combined exercise training improves blood pressure and antioxidant capacity in elderly individuals with hypertension. J Exerc Sci Fit 2019;17:67-76.
4. González PP, Sedlacek J. Exclusive practice of crawl versus practicing the four swimming strokes on the improvement of crawl technique. Retos 2020;40:250-6.
5. Shi Z, Zhou H, Lu L, Pan B, Wei Z, Yao X, Kang YM, Liu LMM, Feng S. Aquatic Exercises in the Treatment of Low Back Pain: A Systematic Review of the Literature and Meta-Analysis of Eight Studies. Am J Phys Med Rehabil 2018;97:116-22.
6. Filatova ZI, Yevtushok M, Okhrimenko IM, et al. Strengthening the physical and mental health of students during swimming classes. Acta Balneol 2022; 3:240-5.
7. Campo AR, Pacichana-Quinayáz SG, Bonilla-Escobar FJ, et al. Effectiveness of hydrotherapy on neuropathic pain and pain catastrophization in patients with spinal cord injury: protocol for a pilot trial study. JMIR Res Protoc 2022;11:e37255-65.
8. Romero-Morales C, López-López D, Almazán-Polo J, et al. Prevalence, diagnosis and management of musculoskeletal disorders in elite athletes: A mini-review. Disease-a-Month 2024;70:101629.
9. Alpert PT. Postural balance: understanding this complex mechanism. Home Health Care Manag Pract 2013;25: 279-81.
10. Andreeva A, Melnikov A, Skvortsov D, et al. Postural stability in athletes: The role of sport direction, Gait & Posture 2021;89:120-5.
11. Salsali M, Sheikhhoseini R, Sayyadi P, et al. Association between physical activity and body posture: a systematic review and meta-analysis. BMC Public Health 2023;23:1670-86.
12. Mitova S, Popova D, Gramatikova M. Modern methods of diagnosis and rehabilitation of postural deformities. Kinesiol Res 2016;44:137-40
13. Yongchao H, Meiling Z, Shi Z, et al. Influence of long-term participation in amateur sports on physical posture of teenagers. Peer J 2022;10:e14520-35.
14. Abbes Z, Monoem H, Abdel-Salam G. Relationship between physical characteristics and 200-metre swimming performance in young amateur swimmers. Acta Kinesiol 2023;17:4-9.
15. Xin W. Core strength training of amateur teen male swimming athlete. Front Sport Res 2020;2:22-6.
16. Ahmet HMM, Bika Lele EC, Guessogo WR, et al. Musculoskeletal pains among amateur and professional athletes of five disciplines in Senegal: a preliminary study. BMC Musculoskelet Disord 2023;24:210-21.
17. Solovjova J, Boobani B, Grants J, et al. Effect of different sports on young athlete's posture swimmers and cyclists, Arch Budo Sci Martial Art Extreme Sport 2023;19:141-9.
18. Lazaridou A, Elbaridi N, Edwards RR, Berde CB. Pain Assessment. In: Benzon HT, Raja SN, Liu SS, Fishman SM, Cohen SP. (eds.) Essentials of Pain Medicine. 2018; pp: 39-46. Elsevier, Berkeley, CA.
19. Feje R, Jordan A, Hartvigsen J. Categorizing the severity of neck pain: establishment of cut points for use

in clinical and epidemiological research. Pain 2005;119: 176–82.
20. Jensen MP, Smith DG, Ehde DM, Robinsin LR. Pain site and the effects of amputation pain: further clarification of the meaning of mild, moderate, and severe pain. Pain 2001;91:317–22.
21. Paul SM, Zelman DC, Smith M, Miaskowski C. Categorizing the severity of cancer pain: further exploration of the establishment of cutpoints. Pain 2005;113:37–44.
22. Olejnik S, Algina J. Generalized eta and omega squared statistics: measures of effect size for some common research designs. Psychol Methods 2003;8:434-47.
23. Messina G, Francavilla VC, Lima F, et al. Effects of proprioceptive insoles and specific core training on postural stability for preventing injuries in tennis. J Funct Morphol Kinesiol 2024;9:34-44.
24. McLeod IA. Swimming anatomy. Human Kinetics, Champaign, IL. 2009.
25. Nikodelis T, Gourgoulis V, Lola A, et al. Front crawl and backstroke sprint swimming have distinct differences along with similar patterns regarding trunk rotations. Int J Kinesiol Sports Sci 2023;11:1-7.
26. Wang HK, Chen CH, Shiang TY, et al. Risk-factor analysis of high school basketball–player ankle injuries: A prospective controlled cohort study evaluating postural sway, ankle strength, and flexibility. Arch Phys Med Rehabil 2006;87:821–5.
27. Trojian TH, McKeag DB. Single leg balance test to identify risk of ankle sprains. Br J Sports Med 2006;40: 610–3.
28. Gonjo T, Fernandes RJ, Vilas-Boas JP, Sanders R. Body roll amplitude and timing in backstroke swimming and their differences from front crawl at the same swimming intensities. Sci Rep 2021;11:824-36.
29. Pink MM, Tibone JE. The painful shoulder in the swimming athlete. Orthop Clin North Am 2000;31:247-61.
30. McKenzie A, Larequi SA, Hams A, et al. Shoulder pain and injury risk factors in intermediate swimmers: A systematic review. Scand J Med Sci Sports 2023;33: 2396-412.
31. Yoma M, Herrington L, Mackenzie TA. The effect of exercise therapy interventions on shoulder pain and musculoskeletal risk factors for shoulder pain in competitive swimmers: a scoping review. J Sport Rehabil 2022;31:617-28.
32. Messina G, Giustino V, Martines F, et al. Orofacial muscles activity in children with swallowing dysfunction and removable functional appliances. Eur J Transl Myol 2019;29:246-50.
33. Abdelmohsen A, Elhafez S, Nabil B. Core stability in adolescent swimmers with swimmer's shoulder syndrome. Physiother Quat 2021;29:33-41.
34. Di Corrado D, Francavilla VC, La Paglia R, et al. Short-Term effects of specific Sensorimotor Training on postural assessment in healthy individuals: A pilot study with a randomized placebo-controlled trial. J Funct Morphol Kinesiol 2023;8:46-55.

Disclaimer

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article or claim that may be made by its manufacturer is not guaranteed or endorsed by the publisher.

Submitted: 24 September 2024.
Accepted: 28 October 2024.
Early access: 4 December 2024.