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Autores



Mário J. Costa, Ph.D.
Professor Auxiliar com Agregação na Universidade de Trás-os-Montes e Alto Douro (UTAD, Portugal) e membro integrado do Centro de Investigação em Desporto, Saúde e Desenvolvimento Humano (CIDESD). Atualmente, exerce funções de Vice-Presidente da Associação Portuguesa de Treinadores de Natação (APTN, Portugal) e é co-responsável pela Comissão APTN Ciência. A sua investigação centra-se na identificação dos fatores determinantes e a quantificação dos mecanismos subjacentes ao treino em desportos aquáticos, abrangendo atletas jovens e seniores. É autor de mais de 100 artigos publicados em revistas indexadas, bem como de vários livros e capítulos de livros. É autor do livro *Avaliação e Controlo do Treino na Natação*, publicado pela Prime Books.



Aldo M. Costa, Ph.D.
Professor Associado com Agregação em Ciências do Desporto na Universidade da Beira Interior (UBI) e investigador do Centro de Investigação em Desporto, Saúde e Desenvolvimento Humano (CIDESD). É Presidente da Associação Portuguesa de Técnicos de Natação (APTN), primeiro Vice-Presidente da Confederação Portuguesa das Associações de Treinadores (CPAT) e membro da Comissão para a Responsabilidade Social e Segurança Aquática da *European Aquatics*.

A sua atividade científica centra-se na literacia e competência aquática, prevenção do afogamento, desenvolvimento da excelência desportiva e responsabilidade social através do desporto. Tem coordenado e participado em diversos projetos nacionais e internacionais, destacando-se o projeto europeu ALFAC – Aquatic Literacy For All Children (Erasmus+ Sport) e a iniciativa de cooperação internacional São Tomé e Príncipe a Nadar.

É autor de mais de 100 artigos científicos publicados em revistas internacionais, bem como de vários livros dedicados à natação, ao desenvolvimento do talento e à segurança aquática. Entre as suas obras mais recentes destacam-se Não Existem Talentos no Vácuo – Perspetivas Científicas sobre o Desenvolvimento da Excelência no Desporto e Estudos em Natação (Partes I e II). O seu trabalho tem contribuído para o desenvolvimento de programas e estratégias de promoção da segurança aquática em Portugal e no contexto europeu.

Catarina C. Santos, Ph.D.



Professora Adjunta Convidada na Universidade Politécnica de Coimbra (UPC-ESEC, Portugal) e membro integrada no Centro de Investigação & Inovação em Desporto, Atividade Física e Saúde (SPRINT). Atualmente, integra os órgãos sociais da Associação Portuguesa de Treinadores de Natação (APTN, Portugal) e é co-responsável pela Comissão APTN Ciência. Os seus interesses de investigação incluem os fatores biomecânicos determinantes das atividades aquáticas, com foco na preparação desportiva a longo prazo na natação de competição. Publicou mais de 60 artigos com revisão por pares, bem como vários livros e capítulos de livro. É autora do livro *Avaliação e Controlo do Treino na Natação*, publicado pela Prime Books.

Editorial

As atividades aquáticas atravessam atualmente um período de profunda transformação. A crescente complexidade dos processos de treino, ensino e gestão exige profissionais cada vez mais qualificados e organizações desportivas capazes de fundamentar as suas decisões em conhecimento sólido, atualizado e cientificamente validado. Neste contexto, a APTN assume como parte integrante da sua missão a valorização da ciência enquanto motor de desenvolvimento do setor.

A publicação deste anuário científico constitui uma iniciativa pioneira no panorama associativo nacional e representa um passo relevante na afirmação da APTN como um verdadeiro espaço de convergência entre o sistema científico e tecnológico e a realidade profissional das atividades aquáticas. Ao assumir este compromisso, a APTN procura desempenhar um papel agregador e mobilizador, funcionando como um *cluster* de conhecimento que aproxima investigadores, treinadores, professores, técnicos de exercício, terapeutas, dirigentes e gestores. Esta aproximação não pode ser entendida como um processo unidirecional. Pelo contrário, assenta numa relação de benefício mútuo: a ciência deve contribuir para tornar a natação e as restantes atividades aquáticas mais relevantes, coerentes e, no caso particular das atividades federadas, mais competitivas; simultaneamente, os desafios emergentes da intervenção profissional devem constituir uma fonte permanente de necessidades e oportunidades para a investigação. É neste equilíbrio que a APTN se procura afirmar há quase cinco décadas; é um desafio, mas também um dos legados mais relevantes que podemos deixar para o futuro da natação e das atividades aquáticas em Portugal.

É importante referir que o presente anuário constitui um exercício particularmente moroso, procurando pela primeira vez, reunir de forma sistematizada uma parte muito significativa da produção científica nacional desenvolvida no domínio das atividades aquáticas ao longo do último ano. As mensagens apresentadas não correspondem à simples soma das conclusões individuais dos estudos, mas à nossa interpretação integrada da evidência científica produzida em 2025, considerando artigos científicos, projetos internacionais e comunicações apresentadas em eventos científicos. Não teríamos conseguido concretizar este trabalho sem o contributo de muitos colegas de instituições de ensino superior que se associaram à iniciativa e, naturalmente, sem a disponibilidade e competência dos professores Mário Costa e Catarina Santos para, no âmbito das iniciativas da Comissão APTN Ciência, assumirem este desafio de sistematização, que espero venha a ter continuidade.

O principal objetivo deste anuário é disponibilizar uma visão integrada da investigação produzida em Portugal, promovendo a sua divulgação e contribuindo para uma maior aproximação entre a evidência científica e a intervenção profissional nas quatro áreas temáticas de formação da APTN: treino, ensino, fitness e terapia aquática, bem como da direção técnica e gestão. O anuário resulta de um processo colaborativo de recolha de informação coordenado pela APTN Ciência, envolvendo Instituições de Ensino Superior e Unidades de Investigação com intervenção nas diferentes áreas das atividades aquáticas. Todas as entidades identificadas foram convidadas a reportar a produção científica desenvolvida ao longo de 2025, incluindo artigos científicos, resumos publicados em eventos científicos e teses académicas. A informação compilada reflete o contributo das instituições que responderam a esta iniciativa, representando uma parte muito significativa das instituições que integram o Sistema Científico e Tecnológico Nacional com atividade no domínio das atividades aquáticas.

Portugal possui uma comunidade científica da natação com enorme impacto internacional, de valor incomensurável para o crescimento sustentado da nossa natação. Sabemos que a intervenção de qualidade depende crescentemente da capacidade de transformar esse conhecimento científico em decisões práticas e com impacto. Este anuário pretende contribuir precisamente para essa ponte entre investigação e ação. Contudo, o nosso maior desafio não se

resume à sistematização e transferência do conhecimento para o terreno, como frequentemente ouvimos de diferentes atores. É igualmente fundamental que a academia se debruce com maior atenção sobre os problemas com que o terreno se confronta diariamente e que procure medir o impacto social e desportivo da investigação produzida. Manter vivo o diálogo entre a academia e o terreno é, por isso, um imperativo que não podemos deixar esmorecer, quaisquer que sejam as dificuldades.

Por:
Aldo Matos da Costa

Comissão APTN Ciência

A Comissão APTN Ciência afirma-se como um pilar estratégico no seio da Associação Portuguesa de Técnicos de Natação (APTN), assumindo um papel central na valorização do conhecimento científico e na promoção de uma cultura de investigação aplicada no domínio das atividades aquáticas. Enquadrada numa visão de desenvolvimento sustentado do setor, esta comunidade procura reforçar a articulação entre ciência, prática profissional e decisão institucional, contribuindo de forma ativa para a qualificação, inovação e credibilidade da intervenção técnica.

Num contexto em que a evolução da prática das atividades aquáticas exige uma base cada vez mais sólida de evidência científica, a APTN Ciência posiciona-se como um espaço de convergência entre os diferentes atores (treinadores, investigadores, docentes e outros profissionais), promovendo o diálogo, a reflexão crítica e a partilha de conhecimento. A sua atuação orienta-se, não apenas para a produção científica, mas também para a sua tradução prática, garantindo que o conhecimento produzido se reflete de forma concreta na melhoria das metodologias de treino, na segurança das práticas e na qualidade global do ensino e da intervenção em meio aquático.

A Comissão desempenha ainda um papel relevante no apoio à Direção da APTN e às restantes comissões e comunidades técnicas, contribuindo para a consolidação de uma cultura científica transversal à Associação. Este apoio materializa-se através da emissão de pareceres técnicos, da colaboração em iniciativas estratégicas e do acompanhamento de projetos de investigação, inovação e desenvolvimento, reforçando a capacidade institucional da APTN para intervir de forma informada e sustentada.

No âmbito das suas iniciativas, destacam-se a coordenação e desenvolvimento do Anuário Científico da APTN, uma publicação que se pretende que agregue e valorize a produção científica nacional relevante, incluindo artigos, dissertações/teses, resumos de conferências e outros contributos. Este anuário constitui não apenas um repositório de conhecimento, mas também um instrumento de afirmação da investigação realizada em Portugal, promovendo a sua visibilidade e incentivando a continuidade da produção científica.

Paralelamente, a Comissão tem vindo a reforçar a ligação ao sistema científico e académico, nomeadamente através do apoio à preparação de candidaturas a bolsas de Doutoramento, na qual a APTN assume o papel de entidade acolhedora. Esta iniciativa reflete o compromisso da Associação com o desenvolvimento de percursos académicos de excelência e com a integração da investigação avançada no contexto profissional.

Outro eixo relevante da sua atuação é a promoção da divulgação científica, materializada no desenvolvimento do concurso de comunicações orais livres a decorrer no congresso anual da APTN. Esta iniciativa visa incentivar a apresentação e discussão de trabalhos científicos e experiências relevantes em áreas temáticas como treino desportivo e performance, ensino da natação e suas vertentes, fitness e terapia aquática, direção técnica e gestão de piscinas. Este é um contributo determinante para a dinamização dos dados mais recentes junto da comunidade técnica e para o reconhecimento do mérito científico no âmbito das atividades aquáticas.

Neste enquadramento, o presente anuário surge como expressão concreta da missão e do trabalho desenvolvido pela APTN Ciência. Mais do que uma compilação de conteúdos, representa um espaço de encontro entre conhecimento e prática, que queremos ver útil para quem exerce atividade diária no cais da piscina.

Por:
Catarina C. Santos
Mário J. Costa

ARTIGOS EM REVISTA

ARTIGOS EM REVISTA

Caracterização geral da produção científica

A produção científica reunida neste capítulo integra 33 artigos publicados em revistas científicas (Tabela 1). A análise quantitativa evidencia uma clara predominância da área temática de Treino Desportivo e Performance (Figura 1), reunindo 25 artigos. Esta distribuição revela que a investigação científica direciona o seu interesse para as subáreas de biomecânica, fisiologia, avaliação e controlo do treino e fatores associados à performance em Natação Pura Desportiva, Polo aquático e Natação Artística. As áreas de Ensino da Natação e suas vertentes, e de Fitness e Terapia Aquática, apresentam uma expressão quantitativa mais reduzida. A primeira integra 4 artigos, com contributos sobre literacia aquática, competência aquática percebida e perceções parentais sobre o estado de competência aquático dos seus filhos. Na segunda, sobressaem estudos relacionados com exercício aquático, terapia aquática, respostas fisiológicas na hidroginástica e intervenção em populações específicas. A área de Direção Técnica e Gestão de Piscinas surge de forma menos representada, com um contributo centrado em integridade, transparência e governação no desporto.

Tabela 1. Identificação e distribuição da produção científica em formato de artigo pelas áreas temáticas em análise.

Área temática	ID
Treino Desportivo e Performance	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 26, 27, 29, 30, 31, 32, 33
Ensino da Natação e suas vertentes	17, 23, 24, 25
Fitness e Terapia Aquática	9, 21, 28
Direção Técnica e Gestão de Piscinas	22

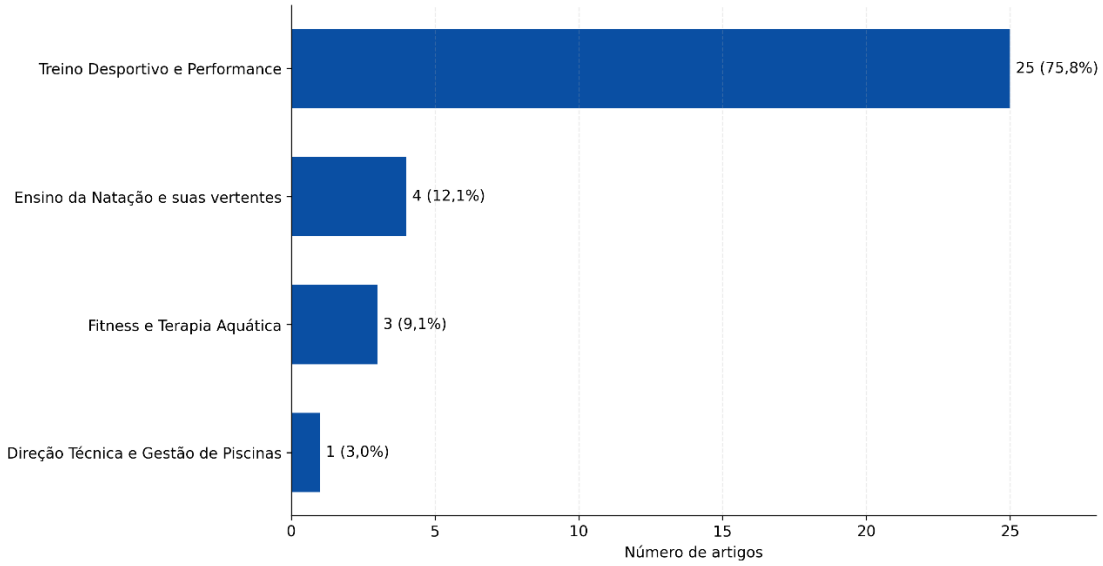


Figura 1. Distribuição percentual dos artigos publicados em revistas científicas por área temática (n = 33).

A Figura 2 revela a participação diferenciada dos investigadores no conjunto de artigos analisados, com alguns autores a assumirem maior presença na produção científica publicada. Esta distribuição poderá traduzir a continuidade de linhas de investigação consolidadas e a participação em redes colaborativas no domínio das atividades aquáticas e de acordo com as áreas temáticas da APTN.

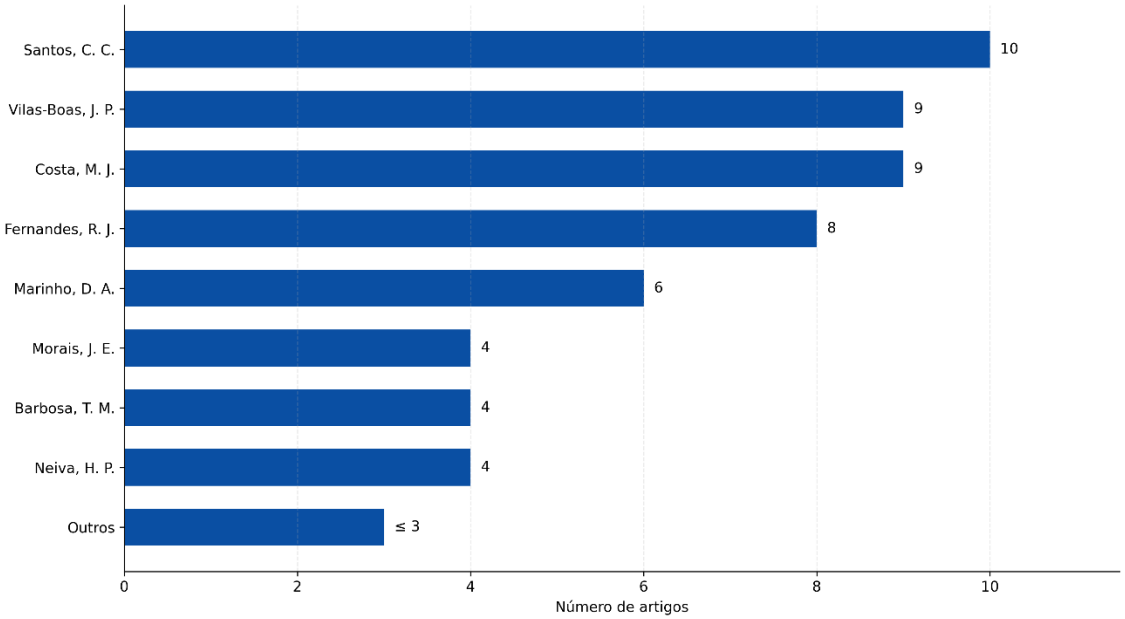


Figura 2. Identificação dos autores com maior número de artigos publicados em revistas científicas no âmbito das atividades aquáticas.

1. Change in young swimmers' anaerobic potential in response to taper

Sampaio, A.R.[1,2,3,4*], Ferreira, F.A.[2,3], Vilas-Boas, J.P.[2,3], Toubekis, A.[5], Fernandes, R.J.[2,3], & Soares, S.[2,3]

[1] Polytechnic Institute of Maia, Research Center of the Polytechnic Institute of Maia, Maia, Portugal
[2] University of Porto, Faculty of Sport, Centre of Research, Education, Innovation and Intervention in Sport, Porto, Portugal
[3] University of Porto, Porto Biomechanics Laboratory, Porto, Portugal
[4] Research Center in Sports Sciences, Health Sciences and Human Development, Vila Real, Portugal
[5] National and Kapodistrian University of Athens, School of Physical Education & Sport Science, Athens, Greece

*Corresponding author: arsampaio@umaia.pt

The current study aims to determine the effect of one-week tapering on the anaerobic potential of young swimmers based on a simple and non-invasive test. Twenty competitive young swimmers (12.83 ± 1.08 years) performed an all-out 25 m front crawl sprint coupled to an electromechanical speedometer before and after a week of taper. The variation of the velocity along time [v/(t) curves] was determined for each swimmer. The push-off maximum velocity, push-off velocity decay, maximum and average gliding velocity, maximum and average swimming velocity, fatigue index, swimming velocity decay, velocity variation coefficient, total number of cycles, and total swim time were calculated. An individual anaerobic fatigue threshold was determined by applying a mathematical procedure based on wavelet analysis to the aforementioned v/(t) curves. The number of upper limb cycles performed was registered using video. The blood lactate concentration was measured at rest and after the 25 m sprint. The swim duration time of 25 m (pretaper: 17.91 ± 1.69; post-taper: 17.90 ± 2.18 s, p = .976) and the post-effort blood lactate (pre-taper: 4.92 ± .85 and post-taper: 4.77 ± 1.80 mmol/l, p = .780) did not change with the taper. The other variables also did not change, except for the velocity decay (-1.19 ± .94 vs. -.52 ± .21 $m \cdot s^{-1}$, p = .016). The moment of occurrence of the anaerobic fatigue threshold was no different after the taper. The one-week taper did not significantly change young swimmers' anaerobic potential.

Referência
Sampaio, A. R., Ferreira, F. A., Vilas-Boas, J. P., Toubekis, A., Fernandes, R. J., & Soares, S. (2025). Change in young swimmers' anaerobic potential in response to taper. *Motricidade*, *21*, e34709, 1–7. https://doi.org/10.6063/motricidade.34709

2. VO2FITTING Software: New Insights and Practical Applications (VO2FITTING Software Update)

Monteiro, A.S.[1*], Azevedo, R. M. S.[2,3], Zacca, R.[4,5], Ogonowska-Slodownik, A.[6], Buzzachera, C.F.[7], Vilas-Boas, J.P.[1], & Fernandes, R.J.[1]

[1] Centre of Research, Education, Innovation and Intervention in Sport and Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, Portugal
[2] Associate Laboratory i4HB - Institute for Health and Bioeconomy, University Institute of Health Sciences (CESPU), Gandra, Portugal
[3] UCIBIO- Applied Molecular Biosciences Unit, Forensics and Biomedical Sciences Research Laboratory, University Institute of Health Sciences (1H-TOXRUN, IUCS-CESPU), Gandra, Portugal
[4] Research Centre in Physical Activity, Health and Leisure, Faculty of Sport, University of Porto, Porto, Portugal
[5] Laboratory for Integrative and Translational Research in Population Health, Porto, Portugal
[6] Faculty of Rehabilitation, Jozef Pilsudski University of Physical Education in Warsaw, Warsaw, Poland
[7] Department of Public Health, Experimental and Forensic Medicine, University of Pavia, Pavia, Italy

*Corresponding author: up201406202@fade.up.pt

This study aimed to present an updated version of VO_2FITTING software, where it is possible to dynamically edit, process, filter and model $\dot{V}O_2$ post-exercise data and to characterize the $\dot{V}O_2$ on/off symmetry along different exercise intensity domains. Validation datasets were developed and applied to four widely used models for describing low, moderate, heavy and severe intensity transitions. Perfect fits were observed and parameter estimates perfectly matched the known inputted values for all available models (standard error = 0; $p < 0.001$). In addition, an experiment with 10 trained swimmers performing a 5 x 200 m front crawl protocol (with 0.05 $m \cdot s^{-1}$ velocity step increments and 3-min passive rest intervals) was conducted. The on- and off-transient phases were symmetrical in their shape since they were both adequately fitted by a mono-exponential regression model and no slow component was observed independently of the intensity domain. Furthermore, the mono-exponential model without time delay best fitted the $\dot{V}O_2$ off-transient data. The mean time constant of the on-transient period value was lower than the respective off-transient for all the intensities (15.8 ± 11.4 vs. 30.8 ± 10.4, 11.3 ± 2.3 vs. 29.7 ± 8.4, 13.9 ± 7.0 vs. 28.7 ± 10.8 and 10.3 ± 4.6 vs. 37.0 ± 9.2 s; $p < 0.05$). VO_2FITTING is valid, free and open-source software for characterizing $\dot{V}O_2$ kinetics during both the exercise and recovery periods, helping researchers to give rapid feedback also about the off-transient kinetic parameters.

Referência
Monteiro, A. S., Azevedo, R. M. S., Zacca, R., Ogonowska-Slodownik, A., Buzzachera, C. F., Vilas-Boas, J. P., & Fernandes, R. J. (2025). VO2FITTING software: New insights and practical applications (VO2FITTING software update). *Journal of Human Kinetics*, *97*, 89–100. https://doi.org/10.5114/jhk/194124

3. Front crawl swimming coordination: a systematic review

Silva, A.F.[1,2*], Seifert, L.[3], Fernandes, R.J.[4], Vilas-Boas, J.P.[4], & Figueiredo, P.[5]

[1] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D), Faculty of Sport, University of Porto, Porto, Portugal
[2] Porto Biomechanics Laboratory, University of Porto, Porto, Portugal
[3] Faculty of Sport Sciences, CETAPS EA3832, University of Rouen Normandy, Mont-Saint-Aignan, France
[4] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D), Faculty of Sport, LABIOMEP (Porto Biomechanics Laboratory), University of Porto, Porto, Portugal
[5] Physical Education Department, College of Education, United Arab Emirates University, Al Ain, Abu Dhabi, United Arab Emirates

*Corresponding author: anafilsilva@gmail.com

Several constraints, including environmental (e.g., aquatic resistance, temperature and viscosity), organismic (e.g., anthropometry, buoyancy) and task-related (e.g., imposed swim speed or stroke rate) impact motor coordination and swimming performance. As motor coordination requires structurally organising intra- and inter-limb coupling, the purpose of this review was to update the literature concerning coordination between the upper-limbs in front crawl swimming. We focused on the effects of biomechanical, physiological, and personal (gender, skill level, and age) factors on coordination and performance. In fact, it could be highlighted that upper-limbs coordination varies with organismic, task and environmental constraints, resulting in several available motor solutions that should be adopted according to how each swimmer deals with occurring constraints. As such, there is no ideal or optimal coordination pattern that youth, learners and less-skilled swimmers should imitate.

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4. Sex and age disparities in water polo-related skills

Noronha, F.[1,2], Canossa, S.[1], Carvalho, D.D.[1,2], Monteiro, A.S.[1,2], Afonso, J.[1], Castro, F.[3], & Fernandes, R.[1,2*]

[1] Centre of Research, Education, Innovation and Intervention in Sport, Faculty of Sport, University of Porto, Porto, Portugal
[2] Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, Portugal
[3] Aquatic Sports Research Group, School of Physical Education, Physiotherapy and Dance, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

*Corresponding author: ricfer@fade.up.pt

Existing research points to sex-specific biological and physiological differences, but the effects of sex and age on water polo-specific motor skills have not yet been sufficiently investigated. The current study investigated sex- and age-related disparities in in-water vertical jump, change of direction ability, sprint performance, aerobic fitness and shot velocity, hypothesising that these variables are related to the players' specific motor performance. Sixty-six players (47 males, 19 females) were split into an adult and a young group (each with n = 33). Two-way (sex and age as factors) analysis of variance and Tukey's post hoc test were employed to evaluate the influence of sex and age on specific water polo skill performance. The male players' in-water vertical jump (135.4 ± 8.1 vs. 121.5 ± 6.1 cm), shot velocity with previous displacement (68.3 ± 6.4 vs. 51.0 ± 2.5 km·h^{-1}) and without displacement (68.5 ± 5.7 vs. 52.2 ± 2.9 km·h^{-1}), 10 m sprint (5.6 ± 0.9 vs. 6.6 ± 0.4 s), aerobic fitness (311.7 ± 92.1 vs. 235.7 ± 70.3 m) and change of direction (3.3 ± 0.4 vs. 3.9 ± 0.4 s) scores were superior to those of female players. No significant age-related differences were observed in shot velocity with previous displacement ($F(1,53) = 2.124$, $p = 0.151$, $\eta^2_p = 0.039$) or 10 m sprint performances ($F(1,62) = 0.935$, $p = 0.337$, $\eta^2_p = 0.015$). Male players outperformed females in most water polo-specific motor skills, while age-related differences were limited.

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5. Relative power to velocity variation: A new quantification method for assessing swimming kinematics

Fernandes, A.[1*], Vilas-Boas, J.P.[1], Fernandes, R.J.[1], & Mezêncio, B.[2]

[1] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D) and Porto Biomechanics Laboratory (LABIOMEP), Faculty of Sport, University of Porto,
Porto, Portugal
[2] Biomechanics Laboratory, School of Physical Education and Sport, University of São Paulo, São Paulo, Brazil

*Corresponding author: alexiafernandes@fade.up.pt

Velocity variation in swimming is commonly assessed using quantification methods that fail to consider the movement mechanical nature in the aquatic environment. The current study proposes the relative power to velocity variation method to evaluate the velocity variation effect in efficiency, accounting the swimmers hydrodynamic drag into the calculation. Twenty regional level swimmers (12 males) performed three 25 m front crawl trials (one at 88 and other at 100 % of their maximum velocity, and another at maximum pace using the velocity perturbation method). Mean, maximum and minimum velocities, stroke rate, length and index, and indexes of coordination and synchronization were obtained for each cycle. The power to overcome drag, power to velocity variation, total mechanical power, intracycle velocity variation (assessed by the coefficient of variation) and difference between maximum and minimum absolute velocities were also computed. Power regressions were performed between mean velocity, standard deviation and the absolute and relative power to velocity variation. Results showed that the absolute and relative power to velocity variation values increased (a = 2.82, b = 1) and decreased (a = 0.07, b = − 2.00, respectively) with the mean velocity increment, while both rose with mean velocity standard deviation (a = 142.31, b = 2.00 and a = 1.14, b = 2.00, respectively). The relative power to velocity variation method offers an advanced understanding of front crawl efficiency and enables predicting its effect on overall swimming performance.

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6. Backstroke performance: Comparison and prediction during incremental swimming

de Jesus, K.[1*], Caetano, N.M.F.[2], Ayala, H.V.H.[3], Coelho, L.S.[4], Vilas-Boas, J.P.[2], & Fernandes, R.J.[2]

[1] Federal University Amazonas (UFAM), Brazil
[2] CIFI2D & LABIOMEP, FADEUP, Porto, Portugal
[3] Pontifical Catholic University, Rio de Janeiro, Brazil
[3] Pontifical Catholic University Paraná, Curitiba, Brazil

*Corresponding author: karladejesus@ufam.edu.br

In the present study, we compared cardiorespiratory, metabolic and coordination profiles across a wide range of backstroke intensities, and predicted swimming speed from these determinants. Five trained swimmers completed an incremental n × 200 m backstroke protocol to exhaustion with 0.05 $m \cdot s^{-1}$ increases and 30 s rest between steps. Oxygen uptake, blood lactate concentration and energy cost were measured, and two-dimensional kinematics were used to obtain the index of coordination. Friedman tests, cross-correlation, linear regression, k-nearest neighbours' regression and generalised additive models were applied. Models were evaluated with leave-one-out cross-validation. Speed rose from 1.15 (1.10-1.20) to 1.37 (1.31-1.43) $m \cdot s^{-1}$, with a concomitant increase in the percentage of the velocity at maximal oxygen uptake from 72.00 (69.30-82.60) to 100%, energy cost from 14.26 (11.06-16.25) to 17.52 (16.18-19.78) $J.kg^{-1}.m^{-1}$ and the index of coordination from -21.99 (-23.49- -20.41) to -17.15 (-19.59- -16.32) % indicating persistent catch-up coordination. Speed showed a strong association with the percentage of velocity at maximal oxygen uptake and moderate associations with the energy cost and the index of coordination (*r* = .89, .42, and .32, respectively). Predictive performance for speed yielded coefficients of determination of r^2 = .80 for linear regression, .86 for k-nearest neighbour regression and .90 for generalised additive models. These findings demonstrate how backstrokers adjust their cardiorespiratory, metabolic, and coordination profiles between incremental efforts, supporting speed prediction from low to severe intensities and assisting coaches in prescribing training aligned with targeted swimming performance outcomes.

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7. Sex-based differences in front crawl and butterfly sprint performance in age-group swimmers

Matjiur, R.[1†], Chainok, P.[1†*], Lauer, J.[2.3], Limroongreungrat, W.[4], de Jesus, K.[5], Zacca, R.[6,7,8,9], Fernandes, R.J.[10], & Vilas-Boas, J.P.[10]

[1] Faculty of Sport Science, Burapha University, Chonburi, Thailand
[2] Brain Mind Institute, School of Life Sciences, Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland
[3] Rowland Institute at Harvard, Harvard University, Cambridge, Massachusetts, United States of America
[4] College of Sport Science and Technology, Mahidol University, Thailand
[5] Human Performance Laboratory, Faculty of Physical Education and Physiotherapy, Federal University of Amazonas, Brazil
[6] Research Center in Physical Activity, Health and Leisure (CIAFEL), Faculty of Sports, University of Porto, Porto, Portugal
[7] Laboratory for Integrative and Translational Research in Population Health (ITR), Porto, Portugal
[8] Nucleus of Research in Human Motricity Sciences, Universidad Adventista de Chile, Chillán, Chile
[9] Laboratory of Sport Physiology, Faculty of Sports, University of Porto, Porto, Portugal
[10] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D) and Porto Biomechanics Laboratory (LABIOMEP-UP), Faculty of Sport, University of Porto, Porto, Portugal

[†]These authors contributed equally to this work.
*Corresponding author: karladejesus@ufam.edu.br

The aim of this study was to identify the key variables influencing 50 m sprint performance in front crawl and butterfly strokes and determine the predominant predictors of sex-related performance differences in each technique in age-group swimmers. Thirty national-level age-group swimmers (15 boys and 15 girls; age 13.5 ± 1.0 years) underwent assessments of anthropometry, biological maturation, neuromuscular performance (dynamic strength index of upper and lower limbs), anaerobic critical velocity, tethered swimming force, and stroke mechanics. Multivariate analyses revealed substantial sex differences ($p < 0.05$), with boys outperforming girls in upper-body force output and anaerobic critical velocity (AnCV). Boys showed a greater AnCV (1.54 vs. 1.45 $m \cdot s^{-1}$) and lower fatigue index (−8.52% in front crawl). Boys and girls had a 27.60 N front crawl force differential and 13.59 N butterfly force difference in the first 10 s of tethered swimming. Controlling for sex and biological maturity, the maximum explained variation (η^2) was found in front crawl tethered swimming force (47%), and butterfly lower limb neuromuscular performance (29%). In front crawl, total push-up peak force (diff: 215.44 N; 95% CI: 1.25 to 3.08; $p < 0.001$) and body height (diff: 0.08 cm; 95% CI: −1.82 to −0.28; $p < 0.001$) were key discriminators, while in butterfly, push-up force (diff: 215.44 N; 95% CI: 1.25 to 3.08; $p < 0.001$) and stroke index (diff: 0.54 $m^2 \cdot s^{-1}$; 95% CI: 1.04 to 2.79; $p < 0.001$) were the most effective predictors. Our findings confirm the predictive ability of upper-limb neuromuscular performance and stroke efficiency in identifying sex-based differences in sprint swimming. The practical implications of these findings are substantial, offering a framework for coaches and sports scientists to improve procedures for training by focusing on technique- and sex-specific performance characteristics at critical stages of athletic development.

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8. Agreement Between a Wristwatch and a Free Optical Sensor with a Chest Strap in Measuring HR Variations During Front Crawl Swimming

Bartolomeu, R. F.[1,2,3,4*], Silva, V.[1], Pereira, A.[1], Morais, G.[1], Sokołowski, K.[5], Strzała, M.[5], Morais, J. E.[2,4], & Teixeira, J. E.[1,2,3,4,6]

[1] Department of Sports and Expressions, Polytechnic of Guarda, Guarda, Portugal
[2] Department of Sport Sciences, Instituto Politécnico de Bragança, Bragança, Portugal
[3] Sport Physical Activity and Health & Innovation Center (SPRINT), Rio Maior, Portugal
[4] Research Centre for Active Living and Wellbeing (LiveWell), Polytechnic of Bragança, Bragança, Portugal
[5] Department of Water Sports, Institute of Sports Sciences, University of Physical Culture, Cracow, Poland
[6] Department of Sports Sciences, Polytechnic of Cávado and Ave, Guimarães, Portugal

*Corresponding author: bartolomeu@ipg.pt

Wearables with optical sensors for heart rate (HR) measurement are widely available in the market. However, their accuracy in water is still underexplored. The aim of the present study was to test the agreement of two different devices for HR monitoring with a chest strap while swimming at different intensities. Twenty male and ten female subjects (mean 19.6 ± 0.7 years old, 173.3 ± 5.4 cm, and 67.1 ± 6.6 kg) performed an intermittent progressive protocol of 3 × 30 s tethered front crawl swimming followed by a 1 min rest period. A chest strap, a wristwatch, and a multi-site optical sensor placed at the temple were used simultaneously. A strong association, an excellent intra-class correlation, and a low mean bias were denoted (R^2 = 0.85, ICC = 0.94, b = −1) between HR_{chest} vs. HR_{temple}. Both indicators increased throughout the test, denoting an increase in accuracy from light to vigorous exercise intensity. HR_{chest} and HR_{watch} showed a moderate association for the whole test (R^2 = 0.23) but a weak association, a poor consistency, and a high mean bias stepwise ($0.01 \leq R^2 \leq 0.06$, $0.03 \leq ICC \leq 0.42$, $-48.1 \leq b \leq -16.1$). During swimming, the HR values from the temple showed a better agreement with the chest strap than those from the wristwatch. The temple reading accuracy might be enhanced by using the device during the dryland warm-up routine.

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9. Effects of a land and aquatic exercise-based program on pain, mobility and quality of life in patients with chronic low back pain: a study protocol for a randomized controlled trial

Borges, J.[1,2†*], Monteiro, D.[1,3†], Silva, F. M.[4,5†], Jacinto, M.[1,3†], Pastilha, T.[6†], & Duarte-Mendes, P.[7,8†*]

[1] ESECS - Polytechnic University of Leiria, Leiria, Portugal
[2] Department of Physical Medicine and Rehabilitation, Unidade Local de Saúde do Baixo Mondego, Figueira da Foz, Portugal
[3] Research Center in Sport Sciences, Health Sciences and Human Development (CIDESD), Covilhã, Portugal
[4] University of Coimbra, CIPER, Faculty of Sport Sciences and Physical Education, Coimbra, Portugal
[5] School of Education and Communication, University of Algarve, Faro, Portugal
[6] Department of Pulmonology, Unidade Local de Saúde do Baixo Mondego, Figueira da Foz, Portugal
[7] Department of Sports and Well-Being, Polytechnic Institute of Castelo Branco, Castelo Branco, Portugal
[8] Sport Physical Activity and Health Research & INnovation CenTer (SPRINT), Santarém, Portugal

†These authors contributed equally to this work.
*Corresponding author: joanaccborges24@hotmail.com; pedromendes@ipcb.pt

Chronic low back pain (CLBP) is a disease with significant functional, emotional and social impact. Several interventions are proposed for its management and exercise is one of main, land-based or water-based. This study describes a randomized controlled trial that will analyze the effect of a combined aquatic and land-based exercise program compared to an aquatic-based program on pain, functional incapacity and quality of life in adults with CLBP. Additionally, it will analyze the effects of exercise cessation in the same outcomes. A blind randomized controlled trial will be developed with a 1:1 allocation ratio. Around 30 adults with mechanical CLBP will be randomly allocated in two groups. The experimental group (ALG) will complete an aquatic and land-based exercise program and control group (AG) will carry out only an aquatic program, both for 8 weeks. Participants will be assessed with Visual Analogue Scale, Oswestry Disability Index, Short-Form 36, Tampa Scale of Kinesiophobia-13 and Modified-Modified Schober Test, collected at baseline (M0), after 8 weeks (M1) and 4 weeks after the end of the intervention (M2). This study may provide a relevant contribution to understand the potential effect of a combined land and aquatic exercise program on pain, functional disability, fear of movement, quality of life and lumbar mobility. The results may provide important information for CLBP management.

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10. The influence of sex on high intensity swimming test

Moreno Lara, J.[1], López-León, I.[1], Leitão, L.[2], Fernandes da Silva, S.[3,4], Sánchez-Oliver, A. J.[1,4*], & Domínguez, R.[1,4]

[1] Department of Human Movement and Sports Performance, University of Seville, Spain
[2] Sciences and Technology Department, Superior School of Education of Polytechnic Institute of Setubal, Setúbal, Portugal
[3] Physical Education Department, University of Lavras, Lavras, Brazil
[4] Studies Research Group in Neuromuscular Responses (GEPREN), University of Lavras, Lavras, Brazil.

*Corresponding author: sanchezoliver@us.es

Differences based on sex have been reported in the energetic and mechanical demands of different exercise modalities; however, no studies have analyzed the influence of sex during high-intensity swimming. The aim of this study was to determine sex-based differences in the response to a high intensity swimming test on performance, fatigue, blood lactate concentrations (BLa) and rating of perceived exertion (RPE). A total of 23 competitive swimmers (11 males; 12 females) performed 8 sets of 50-m at maximum intensity with 2 minutes of recovery intra-sets. Pre-and post-exercise, BLa was analysed. In addition, RPE were administered at the end of each 50-m. Differences were detected in the high intensity swimming test on sex ($\eta^2p=0.566$; $p<0.001$) and time ($\eta^2p=0.233$; $p<0.001$), but not for the interaction time·sex ($p>0.05$). It was reported an effect for time on BLa ($\eta^2p=0.947$; $p<0.001$) and RPE ($\eta^2p=0.559$; $p<0.001$), but not for sex nor the interaction time·sex ($p>0.05$). Although males are faster, not differences were found in BLa, fatigue nor RPE between sexes. These results could be mediated by the all-out nature of the protocol and practical implications suggest that it is not necessary to adapt the training load in high intensity swimming session attending to the sex of the athletes.

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11. Freestyle master's swimming: nationality, sex, and performance trends in World Aquatics competitions (1986–2024)

Ahmad, W.[1], Wilhelm, M.[1], Moreitz, S.[2], Andrade, M. S.[3], Forte, P.[4,5,6], Stanula, A.[7], Nikolaidis, P.[8] T., Cuk, I.[9], Thuany, M.[10], Weiss, K.[11], Rosemann, T.[11], Hill, L.[12], Seffrin, A.[13], & Knechtle, B.[11,14*]

[1] Centre for Rehabilitation & Sports Medicine, Inselspital Bern, University Hospital Bern, Bern, Switzerland
[2] Department of Radiology, Lucerne Cantonal Hospital, Lucerne, Switzerland
[3] Department of Physiology, Federal University of São Paulo, São Paulo, Brazil
[4] CI-ISCE, Higher Institute of Educational Sciences of the Douro, Penafiel, Portugal
[5] Department of Sports Sciences, Instituto Politécnico de Bragança, Bragança, Portugal
[6] Research Center for Active Living and Wellbeing (Livewell), Bragança, Portugal
[7] Department of Swimming and Water Rescue, Institute of Sport Sciences, Academy of Physical Education in Katowice, Katowice, Poland
[8] School of Health and Caring Sciences, University of West Attica, Athens, Greece,
[9] Faculty of Sport and Physical Education, University of Belgrade, Belgrade, Serbia
[10] Faculty of Sport, University of Porto, Porto, Portugal
[11] Institute of Primary Care, University Hospital of Zurich, Zurich, Switzerland
[12] Department of Pediatric Surgery, Research Institute of the McGill University Health Centre, Montreal, Canada
[13] Postgraduate Program in Translation Medicine, Federal University of São Paulo, São Paulo, Brazil
[14] Medbase St. Gallen Am Vadianplatz, St. Gallen, Switzerland

*Corresponding author: beat.knechtle@hispeed.ch

In sports science, freestyle swimming has been thoroughly studied for particular performance-related factors. Nonetheless, it is unknown what countries the top freestyle swimmers are from, especially not for age group swimmers. In addition, the existing research on the performance of master freestyle swimmers has yet to confirm that male swimmers achieve faster times than their female counterparts across all age groups and distances. The current study looked into the nationalities and sexes of the top freestyle swimmers in each age group in World Aquatics competitions for the 50m, 100m, 200m, 400m, and 800m events from 1986 to 2024. The data (derived from (www.worldaquatics.com/masters/archives/masters-archives) were presented using mean, standard deviation, maximum and minimum values, and/or confidence intervals. The year of competition, age, age group, stroke, distance, and first and last names of each swimmer were noted. The nations were then divided into six groups: one group comprising all other countries and the top five nations with the greatest number of appearances in the top 10 fastest freestyle swimming times by distance each year. In freestyle swimming, most swimmers (30.6%) competed in the 50m event (n = 25,094, 10,909 female and 14,185 male), followed by the 100m event (25.6%, n = 20,961, 8,796 female and 12,165 male), the 200m event (17.4%, n = 14,309, 6,729 female and 7,580 male), the 400m event (13.4%, n = 10,956, 5,363 female and 5,593 male), and the 800m event (12.6%, n = 10,317, 5,179 female and 5,138 male). The results from the generalized linear models indicate that sex, age group, and the interaction between sex and age group all had significant effects on the 50m, 100m, 200m, 400m, and 800m races. Specifically, for the 50m races, the effect of sex was significant ($\chi2$ (1) = 3451.941, $p < 0.001$), as was the effect of age group ($\chi2$ (13) = 19,295.169, $p < 0.001$), and the interaction between sex and age group ($\chi2$ (13) = 654.671, $p < 0.001$). The USA demonstrates quantitative dominance by contributing the greatest number of top 10 performers. Additionally, the study highlights

significant sex-based performance differences, with males generally outperforming females in all age categories. This study comprehensively analyzes the performance trends observed in freestyle master swimming for nearly four decades.

Referência

Ahmad, W., Wilhelm, M., Moreitz, S., Andrade, M. S., Forte, P., Stanula, A., Nikolaidis, P. T., Cuk, I., Thuany, M., Weiss, K., Rosemann, T., & Seffrin, A. (2025). Freestyle master's swimming: Nationality, sex, and performance trends in World Aquatics competitions (1986–2024). *PLOS ONE*, *20*(9), e0332040. https://doi.org/10.1371/journal.pone.0332040

12. Origins of the fastest master breaststroke swimmers

Knechtle, B.[1], Andrade, M. S.[2], Ahmad, W.[3], Forte, P.[4], Moreitz, S.[5], Stanula, A.[6], Nikolaidis, P.[7] T., Cuk, I.[8], Thuany, M.[9], Weiss, K.[10], Rosemann, T.[10] & Seffrin, A.[11]

[1] Gesundheitszentrum St. Gallen, St. Gallen, Switzerland
[2] Department of Physiology, Federal University of Sao Paulo, Sao Paulo, Brazil
[3] Sanatorium Kilchberg, Kilchberg, Switzerland
[4] CI-ISCE, Higher Institute of Educational Sciences of the Douro, Penafiel, Portugal
[5] Radiology and Neuroradiology, Institute of Radiology, Spital Zollikerberg, Zurich, Switzerland
[6] Institute of Sport Sciences, Department of Swimming and Water Rescue, Academy of Physical Education in Katowice, Katowice, Poland
[7] School of Health and Caring Sciences, University of West Attica, Athens, Greece
[8] Faculty of Sport and Physical Education, University of Belgrade, Belgrade, Serbia
[9] Faculty of Sport, University of Porto, Porto, Portugal
[10] Institute of Primary Care, University of Zurich, Zurich, Switzerland
[11] Postgraduate Program in Translation Medicine, Federal University of Sao Paulo, Sao Paulo, Brazil

*Corresponding author: beat.knechtle@hispeed.ch

Specific performance-related aspects of the breaststroke have been thoroughly investigated in sports science. However, the nationalities of the fastest master breaststroke swimmers are unknown. The present study investigated the nationalities of the fastest master breaststroke swimmers. For all World Masters Championships held between 1986 and 2024, the year of competition, first name, last name, age, age group, stroke, and distance were recorded for each swimmer. Descriptive data were presented using mean, standard deviation, maximum, minimum, and/or confidence intervals. The top 10 race times for each sex were identified, with the nationalities sorted into six categories. The data were then grouped into the top five nationalities with the most appearances in the breaststroke swimming top 10 by distance each year and all other nationalities. The Kruskal–Wallis H test compared nationality differences, followed by Bonferroni-adjusted pairwise comparisons to identify specific distinctions. Between 1986 and 2024, most swimmers (40.7%) competed in the 50 m event (n = 17575; 7911 women and 9664 men), followed by the 100 m (35.2%, n = 15211; 7158 women and 8053 men), and the 200 m events (24.0%, n = 10373; 4934 women and 5439 men). Germany had the most women swimmers in the top 10 yearly, whereas the country with the highest number of men swimmers in the top 10 per year was the United States of America (USA). Germany, Great Britain, the USA, and Italy were the most frequent nationalities among the top 10 countries across all women's breaststroke distances. For men, the USA, Russia, Germany, and Italy were among the top 10 countries in all men's breaststroke distances. In general, performance differences were observed among various countries across all breaststroke distances for both men and women, with certain countries consistently outperforming others in specific events. Germany tended to have better performances for women, while Russia excelled in the men's events. In summary, differences exist in swimming distance and athlete origin of the fastest master breaststroke swimmers. Germany, Great Britain, the USA, and Italy were the most frequent nationalities among the top 10 countries annually in all women's breaststroke distances. For men, the USA, Russia, Germany, and Italy were among the top 10 countries in all men's breaststroke distances.

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13. Variability of energy cost in breaststroke technique: a systematic review

Alves, M.[1,2,3*], Barbosa, T. M.[4,5], & Vilas-Boas, J. P.[1,2,3]

[1] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D), Porto, Portugal
[2] Porto Biomechanics Laboratory (LABIOMEP-UP), Porto, Portugal
[3] Faculty of Sport, University of Porto, Porto, Portugal
[4] Department of Sport Sciences, Instituto Politécnico de Bragança, Bragança, Portugal
[5] Research Centre for Active Living and Wellbeing (LiveWell), Instituto Politécnico de Bragança, Bragança, Portugal

*Corresponding author: up201505002@edu.fade.up.pt

This study aimed to synthesise the body of knowledge on kinematics, active drag and energetics determinants of energy cost variability in the breaststroke technique. Methodological procedures considering the standards for systematic reviews according to the '"Preferred Reporting Items for Systematic Reviews and MetaAnalyses"' were employed. Searches were conducted in four prominent databases. A total of 1,464 articles were identified, of which 201 met the eligibility criteria. After evaluation, 73 articles were included for synthesis in this review. The included studies had a mean score (± SD) of 9.14 ± 1.76 points regarding the quality assessment. The present review identified three distinct domains of variables: kinematics (including stroke kinematics and coordination parameters), active drag, and energetics. The findings underscored the pivotal role of stroke kinematics, including stroke rate, stroke length, stroke index, and intra-cyclic variations of velocity, in influencing energy cost during breaststroke swimming. Additionally, the analysis highlighted the significance of propulsive and non-propulsive phases, arm-to-leg timing, and buoyancy in breaststroke technique. Notably, breaststroke exhibited higher values of active drag, frontal area, and energy cost, while maintaining lower velocity compared to other swimming techniques. Overall, this synthesis of literature highlights the holistic nature of energy cost in breaststroke swimming.

Referência
Alves, M., Barbosa, T. M., & Vilas-Boas, J. P. (2025). Variability of energy cost in breaststroke technique: A systematic review. *Sports Biomechanics*, *24*(7), 1803–1843.
https://doi.org/10.1080/14763141.2024.2427683

14. Analyzing Breathing Patterns in the Breaststroke Technique Through Dual-Media Kinematics and Fractal Dimension

Alves, M.[1,2,3], Fonseca, P.[2,3], Fernandes, A.[1,2,3], Brito, A. V.[1,2,3], Barbosa, T. M.[4,5], & Vilas-Boas, J. P.[1,2,3*]

[1] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D), Porto, Portugal
[2] Porto Biomechanics Laboratory (LABIOMEP-UP), Porto, Portugal
[3] Faculty of Sport, University of Porto, Porto, Portugal
[4] Department of Sport Sciences, Instituto Politécnico de Bragança, Bragança, Portugal
[5] Research Centre for Active Living and Wellbeing (LiveWell), Instituto Politécnico de Bragança, Bragança, Portugal

*Corresponding author: jpvb@fade.up.pt

The most hydrodynamic swimming position occurs with the head submerged, highlighting the benefit of reduced breathing frequency for efficiency. This study aimed to characterize and compare kinematics between two breaststroke breathing patterns—breathing every cycle and breathing every two cycles—while also analyzing intra-cyclic velocity variation (dv) and fractal dimension. In the breathing every cycle pattern, each cycle included a breath. In the breathing every cycle pattern, swimmers breathed once per cycle. In the breathing every two cycles pattern, breathing occurred every second cycle, resulting in three types of cycles: breathing, non-breathing, and the breathing cycle following a non-breathing cycle. To ensure familiarity with the new breathing pattern, swimmers underwent a six-week intervention program. They then performed three maximal 25 m bouts in each breathing pattern. Kinematic data were collected using a dual-media optoelectronic system (Qualisys AB, Sweden), integrating underwater and dry-land camera recordings. The results showed minimal differences between the three cycle types. The non-breathing cycle had the shallowest and deepest head positions, the lowest horizontal head amplitude out of water, and the smallest vertical head amplitude. It also had the fastest maximum vertical velocity of the feet and maximum center of mass velocity in the swimming direction.

Referência

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15. Swimming speed comparison between two distinct arm pulls during the butterfly swim stroke

Morais, J. E.[1,2*], Marinho, D. A.[3,4], Neiva, H. P.[3,4], Moriyama, I.[5], & Barbosa, T. M.[1,2]

[1] Department of Sport Sciences, Instituto Politécnico de Bragança, Bragança, Portugal
[2] Research Centre for Active Living and Wellbeing (LiveWell), Instituto Politécnico de Bragança, Bragança, Portugal
[3] Department of Sport Sciences, University of Beira Interior, Covilhã, Portugal
[4] Research Centre in Sports, Health and Human Development (CIDESD), Covilhã, Portugal
[5] Department of Health & Sports Sciences, Faculty of Education, Tokyo Gakugei University, Tokyo, Japan

*Corresponding author: morais.jorgestrela@ipb.pt

The aim of this study was to compare the butterfly swimming speed during the insweep phase of two distinct arm pull patterns. Ten national-level swimmers (5 males with 17.5 ± 0.8-years and 5 females with 16.8 ± 0.9-years) were analyzed while performing butterfly all-out trials based on two distinct arm-pull patterns ("bent" and "straight"). The "bent" arm-pull refers to the stroke kinematics they use to swim. The "straight" arm-pull refers to a more extended elbow than they used to swim. Based on discrete variables, swimming speed was faster in the "straight" than the "bent" arm-pull, but not significantly ($p = 0.546$). Non-significant differences were also noted for the remaining discrete variables. Conversely, Statistical Parametric Mapping (SPM, continuous analysis) identified significant differences in swimming speed between ∼42% and ∼60% (insweep phase and the beginning of the upsweep phase; $p = 0.001$), and ∼83% and ∼87% (halfway through the release and recovery, respectively; $p = 0.043$) of the stroke cycle. SPM was more sensitive in identifying differences in swimming speed between arm pulls. Swimmers were faster while performing the "straight" arm pull than with the "bent" arm pull, predominately based on a faster swimming speed during the insweep phase.

Referência
Morais, J. E., Marinho, D. A., Neiva, H. P., Moriyama, S.-I., & Barbosa, T. M. (2025). Swimming speed comparison between two distinct arm pulls during the butterfly swim stroke. International *Journal of Sports Science & Coaching*, *20*(5), 2197–2203. https://doi.org/10.1177/17479541251350363

16. The Associations Between the Swimming Speed, Anthropometrics, Kinematics, and Kinetics in the Butterfly Stroke

Pinto, M. P.[1,2], Neiva, H. P.[1,2], Sampaio, T.[1,2,3], Oliveira, J. P.[1,2,3], Marinho, D. A.[1,2], Barbosa, T. M.[3,4], & Morais, J. E.[3,4*]

[1] Department of Sport Sciences, University of Beira Interior, Covilhã, Portugal
[2] Research Centre in Sports, Health and Human Development (CIDESD), Covilhã, Portugal
[3] Department of Sport Sciences, Instituto Politécnico de Bragança, Bragança, Portugal
[4] Research Centre for Active Living and Wellbeing (LiveWell), Instituto Politécnico de Bragança, Bragança, Portugal

*Corresponding author: morais.jorgestrela@ipb.pt

There is scarce information about what characterizes the swimming speed in the butterfly stroke and the role of thrust in its characterization and prediction. The aim of this study was to compare the fastest and poorest butterfly swimmers based on a set of anthropometric, kinematic, and kinetic variables and to identify the swimming speed predictors. Eight young male swimmers were divided into two equal groups (each group comprising four swimmers). The swimming speed, as well as a set of anthropometric, kinematic, and kinetic variables, were measured. The swimming speed presented significant differences between the groups (p = 0.011, d = 2.18). The stroke frequency (kinematics, p = 0.027, d = 1.69) and thrust (kinetics, p = 0.034, d = 1.57) also presented significant differences between the groups. The swimming speed presented significant correlations with the stroke index (r_s = 0.83, p = 0.011) and thrust (r_s = 0.83, p = 0.011). The swimming speed was predicted by a combination of the stroke frequency and thrust (R^2 = 0.84, p = 0.010). Coaches and athletes must be aware that combining fast stroke frequencies and the generation of greater thrust leads to the fastest swimming speeds.

Referência

Pinto, M. P., Neiva, H. P., Sampaio, T., Oliveira, J. P., Marinho, D. A., Barbosa, T. M., & Morais, J. E. (2025). The associations between swimming speed, anthropometrics, kinematics, and kinetics in the butterfly stroke. *Bioengineering*, *12*(8), 797. https://doi.org/10.3390/bioengineering12080797

17. Principal Technique Components for Young Swimmers Evaluation. Enhancing the Free Observation Method

Papadimitriou, K.[1*], Pinto, M. P.[1,2], Papadimitriou, N.[4], & Neiva, H. P.[1,2]

[1] Department of Nutritional Science and Dietetics, International Hellenic University, Thessaloniki, Greece
[2] Department of Sport Sciences, University of Beira Interior, Covilhã, Portugal
[3] Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, Covilhã, Portugal
[4] Department of Accounting and Finance, International Hellenic University, Thessaloniki, Greece

*Corresponding author: kpapadimitriou@ihu.gr

The study aims to identify, weight, and highlight the mistakes in the four swimming strokes through a technique evaluation tool for young swimmers that can accurately calculate swimming technique scores, taking into account the significance of each mistake. A total of 86 regional-level young swimmers (48 boys and 38 girls), aged from 8 to 12 years old, and training experience of 5.4 (1.7) years, participated in the study. Participants performed 15 m of each one of the swimming strokes (butterfly, backstroke, breaststroke, and front crawl), and were evaluated by two swimming coaches with the Technique Papadimitriou (Tec Pa) tool. A principal component analysis for categorical data (CATPCA) was selected to evaluate the weight of the 12 most significant technical points for all strokes. The range of loads, for the 12 technique spots, in the butterfly stroke was from 0.50–0.75, for backstroke from 0.47–0.68, for breaststroke from 0.51–0.80, and for front-crawl 0.31–0.74, with a Cronbach's Alpha value on 0.91, 0.88, 0.92 and 0.87 for each stroke, respectively. Considering the analysis, swimming coaches can easily implement a swimming technique evaluation for their swimmers without any expensive equipment, complicated systems, or computer applications.

Referência

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18. Can young swimmers guide their pace through the rating of perceived exertion?

Torres, G.[1,2*], Maia, F.[1,2], Oliveira, R.[1], Figueiras, T.[1,3], Neiva, H.[2,4], Nakamura, F.[1,2], & Sousa, A.[1,2]

[1] Universidade da Maia, Maia, Portugal
[2] Centro de Investigação em Ciências do Desporto, Ciências da Saúde e Desenvolvimento Humano, Vila Real, Portugal
[3] Centro de Investigação em Qualidade de Vida, Santarém, Portugal
[4] Universidade da Beira Interior, Covilhã, Portugal

*Corresponding author: gonca.torres@gmail.com

Currently, the most widely used methods for evaluating internal training load rely on heart rate data as a tool to measure exercise intensity. However, there are limited practical methods available for evaluating training load in swimming. Therefore, assessing indirect methods such as the rating of perceived exertion, a psychophysiological tool to assess the subjective perception of effort during exercise, becomes practical and useful. This study aims to link swimming intensities based on rating of perceived exertion values to identify key performance markers such as velocity, stroke length, stroke rate, and heart rate-based methods to verify if the rating of perceived exertion production is a reliable method to prescribe intensity in swimming. Eight (4 male, 4 female) well-trained swimmers (age 15.8 ± 2.3 years) performed nine bouts of 200 m, three in each of the front crawl, backstroke and breaststroke at ratings of perceived exertion of 5 (strong), 7 (very strong) and 9 (extreme) in the CR-10 Borg Scale. Significant effects were observed for rating of perceived exertion in velocity, stroke rate, stroke length, mean and maximum heart rate, while effects of swimming stroke were observed on velocity, stroke rate and stroke length. These findings suggest that producing ratings of perceived exertion of 5, 7 and 9 may be a suitable approach for swimmers to guide their pace in practice settings.

Referência

Torres, G., Maia, F., Oliveira, R., Figueiras, T., Neiva, H. P., Nakamura, F. Y., & Sousa, A. (2025). Can young swimmers guide their pace through the rating of perceived exertion? *Motricidade*, *21*, e40036. https://doi.org/10.6063/motricidade.40036

19. Open Water Swimming: Swimmers' Kinematical and Neuromuscular Characterisation in 5 km Swim

Conceição, A.[1,2*], Marinho, D.A.[2,3], Stastny, J.[4], Gonçalves, C.[5], Freitas, J.[1,2], da Costa-Machado, R.[1,2,3], & Louro, H.[1,2]

[1] Department of Sport Sciences, Sport Sciences School of Rio Maior, Polytechnic Institute of Santarém, Santarém, Portugal
[2] Research Center in Sports Sciences, Health Sciences and Human Development (CIDESD), Covilhã, Portugal
[3] Department of Sport Sciences, University of Beira Interior, Covilhã, Portugal
[4] Centre of Sports Activities, Brno University of Technology, Brno, Czech Republic
[5] Department of Sport Sciences, Faculty of Sports Sciences of Cáceres, University of Extremadura, Cáceres, Spain

*Corresponding author: anaconceicao@esdrm.ipsantarem.pt

This study aimed to characterize and analyse the kinematic parameters and muscle activity of swimmers in open water swimming (OWS). Nine male swimmers (age: 25.4 ± 11.9 years; body mass: 75.9 ± 9.0 kg; height: 180.7 ± 6.7 cm; and arm span: 185.6 ± 10.3 cm) were evaluated in an open environment (lake), performing 5 m × 1000 m at maximum intensity, with a rest of 30 s every 1000 m. For kinematical analyses, the stroke rate (SR), swimming velocity (v), stroke length (SL), and stroke index (SI) were calculated. Surface EMG data were recorded in seven muscles—upper trapezius (UP); latissimus dorsi (LD); pectoralis major (PM); posterior deltoid (PD); anterior deltoid (AD); triceps brachii (TB); and biceps brachii (BB)—for the underwater and recovery phases of the stroke. SL ($F = 3.41$, $p = 0.06$, $\eta^2 = 0.30$) and SI ($F = 3.29$, $p = 0.08$, $\eta^2 = 0.29$) changed along the covered distances, and SR ($F = 1.54$, $p = 0.24$, $\eta^2 = 0.16$) increased, especially in the last 1000 m (32.5 ± 3.0 cycles·min^{-1}). AD was highly activated in recovery, showing statistical differences from the beginning ($p \leq 0.01$) to the end of the race ($p = 0.03$). The TB muscle was mostly recruited in the underwater phase, from the start ($p \leq 0.01$) to the finish ($p = 0.03$), showing a significant difference in each lap, with a large effect. LD showed significant differences in muscle activation, from 1000 m ($p \leq 0.01$) with a huge effect, to 5000 m ($p \leq 0.01$), with a large effect. These results suggested that the UT and AD muscles had higher activity in recovery than the underwater phase, and TB and LD were higher in the underwater phase.

Referência

Conceição, A., Marinho, D. A., Stastny, J., Gonçalves, C., Freitas, J., da Costa-Machado, R., & Louro, H. (2025). Open water swimming: Swimmers' kinematical and neuromuscular characterisation in 5 km swim. *Sports*, *13*(10), 335. https://doi.org/10.3390/sports13100335

20. Comparison of the Active Drag and Passive Drag Coefficients at the same Swimming Speed Through Experimental Methods

Lopes, T.J.[1,2*], Sampaio, T.[1,2,3], Pinto, M.P.[1,2], Oliveira, J.P.[1,2,3], Marinho, D.A.[1,2], & Morais, J.E.[3,4]

[1] Department of Sport Sciences, University of Beira Interior, Covilhã, Portugal
[2] Research Centre in Sports, Health and Human Development (CIDESD), Covilhã, Portugal
[3] Department of Sport Sciences, Instituto Politécnico de Bragança, Bragança, Portugal
[4] Research Centre for Active Living and Wellbeing (LiveWell), Instituto Politécnico de Bragança, Bragança, Portugal

*Corresponding author: tiago_lopes_17@hotmail.com

Studies about drag in swimming usually report or put the focus on its absolute value. However, it is being claimed that the drag coefficient better represents the hydrodynamic profile of a swimmer. Drag is strongly dependent on speed. Thus, increases in speed will lead to increases in drag. This could lead to misleading interpretations since drag is the water resistance that makes the swimmers' displacement difficult. Conversely, the drag coefficient is less dependent on speed, which can be seen as a more appropriate measure of the swimmers' hydrodynamic profile. This study used a complete experimental methodology (experimental and cross-sectional study) to determine the resistive forces in crawl swimming at the same speed (i.e., 1.00, 1.05, 1.10 m/s, etc.). In 10 proficient non-competitive adult swimmers (seven men and three women), the drag coefficient (C_D) was compared and the difference between using the technical drag index (TDI) with drag (D, passive or active) or with its respective C_D's. Measurements of active drag (D_A), passive drag (D_P) and C_D (C_{DA} and C_{DP}) were carried out. The TDI was calculated as a measure of swimming efficiency and the frontal surface area (FSA) obtained in active conditions. The active FSA was 20.73 ± 5.56% greater than the passive FSA (large effect size), the propulsion was 58.29 ± 69.61% greater than drag and C_{DA} was 24.60 ± 46.55% greater than C_{DP} (moderate effect size). TDI was significantly lower, but with a small effect size when measured with C_D values compared to drag. TDI_D vs TDI_{CD} revealed strong agreement (> 80% of plots were within IC95). This study concludes that proficient swimmers presented a C_{DA} greater than the CDP, but with strong agreement between them, probably due to FSA during active conditions. C_D data appears to be a more absolute indicator of drag than TDI.

Referência

Lopes, T. J., Sampaio, T., Pinto, M. P., Oliveira, J. P., Marinho, D. A., & Morais, J. E. (2025). Comparison of the active drag and passive drag coefficients at the same swimming speed through experimental methods. *Montenegrin Journal of Sports Science and Medicine*, *21*(1). Advance online publication. https://doi.org/10.26773/mjssm.250309

21. Enhancing coordination and well-being: the impact of swimming and aquatic therapy for individuals with intellectual disabilities

Oltean, A.[1,2], Batalha, N.[3,4], & Gidu, V.[1]

[1] Ovidius University of Constanta, Romania, Aleea Cpt A. Serbanescu no.1
[2] Doctoral School of Sport Science and Physical Education, Institute of Doctoral Studies, Ovidius University of Constanța, Romania
[3] Departamento de Desporto e Saúde, Escola de Saúde e Desenvolvimento Humano, Universidade de Évora, Évora, Portugal
[4] Comprehensive Health Research Centre (CHRC), University of Évora, Évora, Portugal

*Corresponding author: olteantoanela@gmail.com

Swimming is a valuable intervention for improving coordination in individuals with intellectual disabilities (ID). The unique properties of water—such as buoyancy and resistance—create an ideal environment for enhancing motor skills, balance, and strength, particularly for individuals with ID who face challenges in land-based activities. This article explores the impact of swimming on coordination, focusing on the benefits of aquatic therapy, specific swimming techniques, and social and cognitive development. Structured aquatic programs offer a safe and supportive setting where individuals can refine their motor skills and enhance their physical fitness. Studies have shown that swimming improves balance, muscle strength, and overall coordination in individuals with ID, while also fostering social interaction and cognitive growth. Techniques such as the catch-up coordination model, which emphasizes the synchronization of arm movements during the swimming stroke, have proven effective in improving motor control and stroke efficiency. Additionally, aquatic therapy provides a low-impact exercise option for individuals with physical limitations, making it a sustainable lifelong fitness activity. Participation in group swimming sessions further supports social development, improving communication skills and reducing feelings of isolation. Aquatic therapy, particularly for children with conditions like Down syndrome and autism spectrum disorder, has demonstrated significant benefits in motor coordination and emotional well-being. Swimming also contributes to cognitive development by stimulating attention, memory, and problem-solving skills. This article underscores the importance of incorporating swimming into therapeutic programs for individuals with ID, advocating for the continued use of structured swimming interventions. Future research should explore the long-term benefits of swimming, particularly regarding sustained coordination improvements and the broader effects on physical and emotional health in individuals with intellectual disabilities.

Referência
Oltean, A., Batalha, N., & Gidu, D. V. (2025). Enhancing coordination and well-being: The impact of swimming and aquatic therapy for individuals with intellectual disabilities. *Ovidius University Annals, Series Physical Education and Sport/Science, Movement and Health*, *25*(1), 91–95

22. Integrity and Transparency in Sports: A Survey Review

Costa, S.[1,3], Silva, A.J.[1,2,3], Dias, T.[2,4], Marinho, D.A.[2,3,5], Batalha, N.M.[3,6,7], Roque, R.[2,4], Afonso, C.[2,4], Aminova, M.[8], & Ferraz, R.[2,4]*

[1] Department of Sports, Exercise and Health Sciences, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal
[2] Research Centre in Sports Sciences, Health Sciences and Human Development (CIDESD), Vila Real, Portugal
[3] Portuguese Swimming Federation, Portugal
[4] Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal
[5] Centre of Investigation in Sport, Health and Human Development, University of Beira Interior, Portugal
[6] Department of Sport and Health, University of Évora, Évora, Portugal
[7] Comprehensive Health Research Centre, University of Évora, Evora, Portugal
[8] Brussels School of Governance, Vrije University Brussels, Belgium

*Corresponding author: ricardompferraz@gmail.com

Over the years, integrity and transparency have become the fundamental pillars of ethical conduct in sports, ensuring equal and fair competition. However, in recent years, concerns about various ethical issues and misconduct in sports have emerged and garnered considerable attention from researchers. In response to these issues, this article aims to provide a comprehensive analysis of the literature, attempting to identify fundamental indicators of integrity and transparency in sports that can be measured and assessed. The research methodology employed a set of search terms that were combined in multiple ways with various keywords, including “sports,” “determinants,” “indicators,” “integrity,” “transparency,” “responsibility,” and “governance.” The period of analysis spanned from 2000 to the present day. A filter was applied to remove duplicates, incomplete documents, studies prior to 2000, and studies in other fields. Finally, after using these specific criteria, a total of 38 articles were selected for further analysis. The results indicate that a total of 15 indicators can be measured and controlled for the world of sport to prosper in terms of integrity, ethics, and transparency.

Referência
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23. Translation and Face Validity of the Portuguese Version of the Pictorial Scale of Perceived Water Competence

Reis, L. M.[1], Costa, A. M.[1], Morgado, L. S.[2], Martelaer, K. D.[3], D'Hondt, E.[3], Sääkslahti, A.[4], Howells, K.[5], Barnett, L.M.[6], Silva, A.J.[1], Garrido, N.D.[1], & Jidovtseff, B.[2]

[1] Research Center in Sports, Health and Human Development (CIDESD), Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal
[2] Research Unit for a Life-Course Perspective on Health and Education, Department of Physical Activity and Rehabilitation Sciences, University of Liège, Liège, Belgium
[3] Research Unit on Movement and Nutrition for Health and Performance, Department of Movement and Sport Sciences, Faculty of Physical Education and Physiotherapy, Vrije Universiteit Brussel, Brussels, Belgium
[4] Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland
[5] School of Psychology and Life Sciences, Faculty of Science, Engineering and Social Sciences, Canterbury Christ Church University, Canterbury, United Kingdom
[6] Institute for Physical Activity and Nutrition, School of Health and Social Development, Faculty of Health, Deakin University, Geelong, VIC, Australia

*Corresponding author: b.jidovtseff@uliege.be

The Pictorial Scale of Perceived Water Competence is a tool used to measure self-perception of water competence in children aged from 5 to 8. The aim of this study was to translate the tool into Portuguese and to evaluate the face validity in 120 children ages from 5 to 8 years from Portugal. Individual interviews were conducted with children to assess familiarity with the 17 Pictorial Scale of Perceived Water Competence aquatic skills and their ability to sequence the scale correctly and logically. Familiarity with aquatic skills (88.2%) and ability to sequence (95.0%) and to logically explain the sequence (97.0%) were high. Nevertheless, these scores were lower ($p < .05$) in the children aged 5. In addition, a dependency relationship between children's familiarity, sequencing, and comprehension of skills with previous aquatic experience was observed when controlled by age—in favor of more experienced children ($p < .05$). The Portuguese version of the Pictorial Scale of Perceived Water Competence is well adapted tool for children aged 5–8 years with aquatic experiences and shows very-high level of skill familiarity and good ability to sequence and justify skill progression. However, younger children and those with no previous aquatic experience may have less familiarity and understanding of aquatic skills.

Referência

Reis, L. M., Costa, A. M., Morgado, L. S., Martelaer, K. D., D'Hondt, E., Sääkslahti, A., Howells, K., Barnett, L. M., Silva, A. J., Garrido, N. D., & Jidovtseff, B. (2025). Translation and face validity of the Portuguese version of the Pictorial Scale of Perceived Water Competence. J*ournal of Motor Learning and Development*, *13*(3), 802–816. https://doi.org/10.1123/jmld.2024-0057

24. Improving Water Safety and Long-term Engagement in Aquatic Physical Activity: The Aquatic Literacy Framework

Mekkaoui, L.[1*], Vogt, T.[2], Camporelli, F.[3], Costa, A.M.[4,5,6], Costa, M. J., Martelaer, K.D.[7], D'Hondt, E.[7], Garrido, N.D.[5,6,8], Gandrieau, J.[9], Kwasna, A.[10], Ljødal, I.[11], Olstad, B.H.[11], Rejman, M.[11], Rudnik, D.[11], Santos, C.C.[5,12,13], Schnitzler, C.[2,14], Simonsen, E.[11], Soares, S.[12,15], Staub, I.[2], Van Droogenbroeck, L.[7], & Potdevin, F[1].

[1] Univ. Lille, Univ. Artois, Univ. Littoral Côte d'Opale, ULR 7369 - URePSSS - Unité de Recherche Pluridisciplinaire Sport Santé Société, Lille, France
[2] Institute of Professional Sport Education and Sport Qualifications, German Sport University Cologne, Cologne, Germany
[3] E3S laboratory (UR 1342), University of Strasbourg, Strasbourg, France
[4] Department of Sport Sciences, University of Beira Interior, Covilhã, Portugal
[5] Research Center in Sport Sciences, Health Sciences and Human Development, CIDESD, Vila Real, Portugal
[6] Portuguese Swimming Coaches Association (APTN), Rio Maior, Portugal
[7] Movement and Nutrition for Health and Performance (MOVE) Research Group, Department of Movement and Sport Sciences, Faculty of Physical Education and Physiotherapy, Vrije Universiteit Brussel, Brussels, Belgium
[8] University of Trás-os-Montes and Alto Douro, Vila Real, Portugal
[9] Université Côte d'Azur, LAMHESS, Nice, France
[10] Faculty of Physical Education and Sport, Wroclaw University of Health and Sport Sciences, Wroclaw, Poland
[11] Department of Physical Performance, Norwegian School of Sport Sciences, Oslo, Norway
[12] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D), Faculty of Sport, University of Porto, Porto, Portugal
[13] Department of Sport Sciences, Higher Institute of Educational Sciences of the Douro (ISCE-Douro), Penafiel, Portugal
[14] Teaching and Research Unit in Physical Education and Sport, HEP-VD, Canton de Vaud, Switzerland
[15] Porto Biomechanics Laboratory (LABIOMEP-UP), Porto, Portugal

*Corresponding author: lea.mekkaoui@gmail.com

Young people worldwide are affected by two main health-related issues: physical inactivity and drowning accidents. Encouraging participation in aquatic physical activities in a safe way could address this dual concern. Aligning theoretical frameworks of physical literacy and water competencies could empower young people with key skills to engage safely and sustainably in aquatic environments. The aim of this theoretical paper is to provide a philosophical, ontological, and epistemological rationale for merging these two frameworks into a new concept: aquatic literacy. The multidimensional concept is presented and describes the intertwined physical, psychosocial, and cognitive domains, which provide a means to empower young people to safely enjoy aquatic opportunities and achieve individual health benefits. This new concept needs supportive empirical data, such as the level of individuals in each domain of aquatic literacy, to be a strong framework for guiding aquatic educators and stakeholders to better engage and protect people worldwide.

Referência
Mekkaoui, L., Vogt, T., Camporelli, F., Costa, A. M., Costa, M. J., Martelaer, K. D., D'Hondt, E., Garrido, N. D., Gandrieau, J., Kwasna, A., Ljødal, I., Olstad, B. H., Rejman, M., Rudnik, D., Santos, C. C., Schnitzler, C., Simonsen, E., Soares, S., Staub, I., … Potdevin, F. (2025). Improving water safety and long-term engagement in aquatic physical activity: The Aquatic Literacy Framework. *Journal of Teaching in Physical Education*. Advance online publication. https://doi.org/10.1123/jtpe.2024-0244

25. Parental perceptions about children's ability to swim: a study with 6 to 10 year olds

Costa, M.J.[1], Santos, C.C.[2,3], Soares, S.[1], Garrido, N.D.[2,4], Saraiva, H.[5], & Costa, A.M.[4,5]

[1] Centre of Research, Education, Innovation, and Intervention in Sport, CIFI2D and Porto Biomechanics Laboratory, LABIOMEP-UP, Faculty of Sport, University of Porto, Portugal
[2] University of Trás-os-Montes and Alto Douro, Vila Real, Portugal
[3] Higher Education School, Polytechnic of Coimbra, Coimbra, Portugal
[4] Research Center in Sport Sciences, Health Sciences and Human Development, CIDESD, Vila Real, Portugal
[5] University of Beira Interior, Covilhã, Portugal

*Corresponding author: mjcosta@fade.up.pt

Parental perceptions of aquatic competence can serve as a potential indicator of how aware and involved adults are in supervising children in aquatic environments. This study aimed to compare parental perception with children's actual aquatic competence in a sample of 6-to 10-year-olds. Eighty-one children (8.52 ± 1.11 years old) enrolled in swimming lessons were evaluated on structured aquatic tasks, while their parents completed a questionnaire about their children's skills. Most children (61.7%) were able to stay afloat without foot support. Among those, 97.9% could maintain their head above water and breathe for 30 seconds, 93.6% swam 10 meters, and only 42.3% completed 25 meters using a formal swimming technique. No significant differences were found between parental perception and actual performance. The strongest effect size was observed in basic flotation ability (V = 0.800). These findings highlight the importance of regular participation in swimming lessons, accompanied by ongoing parental awareness of children's aquatic skill development.

Referência
Costa, M. J., Santos, C. C., Soares, S., Garrido, N. D., Saraiva, H., & Costa, A. M. (2025). Parental perceptions about children's ability to swim: A study with 6 to 10 year olds. *Cuadernos de Psicología del Deporte*, *25*(2), 220–229. https://doi.org/10.6018/cpd.632251

26. Relationship Between Front Crawl Trunk Incline and Lower Limbs' Biomechanics in Non-Expert Swimmers

Costa, M.J.[1*], Machado, M.L.[1], Piserchia, P.[2], Hamaoui, A.[2], & Santos, C.C.[3,4]

[1] Centre for Sports Research, Education, Innovation, and Intervention in Sport, CIFI2D, Faculty of Sport, University of Porto, Porto, Portugal
[2] Faculty des Sciences du Sport, University Paris-Saclay, Bures-sur-Yvette, France
[3] Department of Sport Sciences, Exercise and Health, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal
[4] Higher Education School, Polytechnic of Coimbra, Coimbra, Portugal

*Corresponding author: mjcosta@fade.up.pt

This study examined the relationship between front crawl trunk incline and the lower limbs' biomechanics in non-expert swimmers. Eighteen male participants (19.22 ± 1.11 years) were recorded in the sagittal plane performing 2 × 25 m of front crawl at maximum intensity to analyze their trunk incline (TI), maximum knee angle (KneeMax), minimum knee angle (KneeMin), knee range of motion (KneeROM), kicking duration (KickDur), descendent phase duration (DurDesc), and ascendant phase duration (DurAsc). They also performed towing for passive drag measurements and a 20 s lower limbs' tethered test while connected to an electromechanical device and grabbing a floating board to collect the maximum (Fmax) and mean (Fmean) kicking forces. Pearson's correlation coefficient (r) was used to compute the relationships between all variables. For kinematics, a negative association was found between the TI and v (r = −0.64), KneeMin (r = −0.68), KneeRoM (r = −0.74), and SI (r = −0.52). Regarding kinetics, a single association was found between TI and Fmean (r = −0.52). The results indicate that a greater TI in non-expert swimmers may be a consequence of weaker knee action, which compromises their mean force application and negatively affects velocity and efficiency.

Referência
Costa, M. J., Machado, M. L., Pserchia, P.-A., Hamaoui, A., & Santos, C. C. (2025). Relationship between front crawl trunk incline and lower limbs' biomechanics in non-expert swimmers. *Applied Sciences*, *15*(12), 6676. https://doi.org/10.3390/app15126676

27. Evolution of documents related to strength training research on competitive swimmers: a bibliometric review

Venâncio, T.F.[1,2,3,4*], Costa, M.J.[5], Santos, C.C.[6,7], Batalha, N.M.[8,9], Hernadéz-Beltrán, V.[2], Gamonales, J.M.[2,10], & Espada, M.C.[1,3,9,11,12]

[1] SPRINT Sport Physical Activity and Health Research & Innovation Center, Centro de Investigação e Inovação em Desporto Atividade Física e Saúde (SPRINT), Rio Maior, Portugal
[2] Training Optimization and Sports Performance Research Group (GOERD), Faculty of Sport Science, University of Extremadura, Cáceres, Spain
[3] Life Quality Research Centre (CIEQV), Instituto Politécnico de Setúbal, Santarém, Portugal
[4] Biosciences Higher School of Elvas, Polytechnic Institute of Portalegre, Elvas, Portugal
[5] Centre of Research, Education, Innovation, and Intervention in Sport (CIFI2D) and Porto Biomechanics, Laboratory (LABIOMEP-UP), Faculty of Sport, University of Porto, Porto, Portugal
[6] Higher Education School (ESEC), Polytechnic of Coimbra, Coimbra, Portugal
[7] Department of Sport Sciences, Exercise and Health, University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal
[8] Departamento de Desporto e Saúde, Escola de Saúde e Desenvolvimento Humano, Universidade de Évora, Évora, Portugal
[9] Comprehensive Health Research Centre (CHRC), Universidade de Évora, Évora, Portugal
[10] Faculty of Education and Psychology, University of Extremadura, Badajoz, Spain
[11] Instituto Politécnico de Setúbal, Escola Superior de Educação, Setúbal, Portugal
[12] Centre for the Study of Human Performance (CIPER), Faculdade de Motricidade Humana, Universidade de Lisboa, Lisbon, Portugal

*Corresponding author: tiagovenancio@ipportalegre.pt

The purpose of this study is to conduct a bibliometric and scoping review to map the evolution of scientific literature on strength training in competitive swimmers. Web of Science database was used considering the time frame between 1980 and 2024. The following terms were used to search documents: “swimmers”, “strength”, and “training”. A total of 460 documents were included for statistical analysis. Until 2000, fewer than 5 manuscripts were published annually, and only after 2011 did the number regularly exceed 20, peaking in 2021 with 43 publications. Among the top 10 authors, 7 are Portuguese, each with at least 7 published papers. A total of 726 institutions were identified, with 29 having published at least 5 studies. The “Universidade da Beira Interior” had the most publications (20), while the “University of Copenhagen” received the most citations (619) with just 3 papers. Sixty countries contributed overall, with 10 publishing at least 20 documents; the United States of America led with 83. The most prominent keywords over time were “sports performance”, “speed,” and “swimming performance”. These results highlight that bibliometric analysis provides pertinent information, very useful regarding research trends and networks, aiming for future research on the topic of strength in swimmers.

Referência

Venâncio, T. F., Costa, M. J., Santos, C. C., Batalha, N. M., Hernández-Beltrán, V., Gamonales, J. M., & Espada, M. C. (2025). Evolution of documents related to strength training research on competitive swimmers: A bibliometric review. *Frontiers in Sports and Active Living*, *7*, 1603576. https://doi.org/10.3389/fspor.2025.1603576

28. Physiological Responses and Perceived Effort of Older Women When Using Different Buoyant Dumbbells in a Water Fitness Exercise: A Pilot Study

Santos, C.C.[1,2,3*], Kanitz, A.C.[4], Carrijo, V.[5,6], Souza, L.[5], Farinha, C.[7,8], & Costa, M.J.[5,6]

[1] Department of Sport Sciences, Exercise and Health, University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal
[2] Higher Education School, Polytechnic of Coimbra, Coimbra, Portugal
[3] Department of Sport Sciences, Higher Institute of Educational Sciences of the Douro (ISCE-Douro), Penafiel, Portugal
[4] School of Physical Education, Physiotherapy and Dance (ESEFID), Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, Brazil
[5] Center of Research, Education, Innovation, and Intervention in Sport (CIFI2D), Faculty of Sport, University of Porto, Portugal
[6] Porto Biomechanics Laboratory (LABIOMEP-UP), Faculty of Sport, University of Porto, Porto, Portugal
[7] Department of Sports and Well-Being, Polytechnic Institute of Castelo Branco, Castelo Branco, Portugal
[8] Sport Physical Activity and Health Research & INnovation Center (SPRINT), Santarém, Portugal

*Corresponding author: catarinasantos@utad.pt

The use of buoyant equipment in water fitness sessions appears to elicit a more intense physiological response in water exercises. However, it remains unknown whether the shape of the equipment influences these responses. The present study aimed to analyze and compare the physiological responses and perceived effort while older women using different buoyant dumbbells during horizontal adduction/abduction of the upper limbs (HA exercise). Ten older women (76.1 ± 5.3 years of age) attended two assessment sessions to perform HA exercise at a music cadence of 120 bpm with different buoyant dumbbells (one pair for each session): round hydro and hydro crystal. Mean heart rate (HR), systolic and diastolic blood pressures (SBP and DBP, respectively), double product (DPr), blood lactate concentration ([La^-]), and rate of perceived effort (RPE) were assessed according to pre-exercise (rest), warm-up and the HA exercise (five min effort). The mean HR was also analyzed according to the percentage (%) of the predicted maximal theoretical HR (HRmax). Older women reached ~56 and 61% of HRmax using crystal and round dumbbells, respectively. Differences were found in mean HR, [La^-], and RPE with the round dumbbell showing greater values than the crystal dumbbell. Although no differences were found in SBP and DBP, DPr was higher when women used the round dumbbells. The shape of buoyant dumbbells seems to define acute responses of older women as the round dumbbell promotes a more intense physiological response and perceived effort when compared to the crystal dumbbell.

Referência

Santos, C. C., Kanitz, A. C., Carrijo, V. H. V., Souza, L., Farinha, C., & Costa, M. J. (2025). Physiological responses and perceived effort of older women when using different buoyant dumbbells in a water fitness exercise: A pilot study. *Physiologia*, *5*(3), 19. https://doi.org/10.3390/physiologia5030019

29. Understanding upper limbs in-water force in young swimmers with Statistical Parametric Mapping analysis

Santos, C.C.[1,2*], Ruiz-Navarro, J.J.[3], Martinho, D.[4,5], Ferreira, F.A.[6], Marinho, D.A.[7,8], & Costa, M.J.[6]

[1] Department of Sport Sciences, Exercise and Health, University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal
[2] Higher Education School, Polytechnic of Coimbra, Coimbra, Portugal
[3] Aquatics Lab, Department of Physical Education and Sports, Faculty of Sport Sciences, University of Granada, Granada, Spain
[4] University of Coimbra, Research Unit for Sport and Physical Activity, Faculty of Sport Sciences and Physical Education, Coimbra, Portugal
[5] Laboratory of Robotics and Engineering Systems, Interactive Technologies Institute, Funchal, Portugal
[6] Centre of Research, Education, Innovation, and Intervention in Sport (CIFI2D), Faculty of Sport, University of Porto, Porto, Portugal
[7] Department of Sport Sciences, University of Beira Interior, Covilhã, Portugal
[8] Research Center in Sport Sciences, Health Sciences and Human Development (CIDESD), Covilhã, Portugal

*Corresponding author: catarinasantos@utad.pt

The present study aimed to compare swimmers' in-water force according to swimming performance tiers within the same age group and compare the dominant and non-dominant upper limbs within the same tier throughout continuous and discrete analyses. Fifty-two young swimmers (girls and boys: 12.13 ± 0.71 years) were split up into two tiers based on the mean speed: Tier-1 (n = 28), low-tier; and Tier-2 (n = 24), top-tier. In-water forces of upper limbs were assessed with a differential pressure system composed of two hand sensors during 25 m front crawl swimming. Force-time curves of the underwater paths and the mean peak force (FPEAK, N) were considered for further analysis using discrete and continuous analyses (Statistical Parametric Mapping, SPM). Results showed that top-tier swimmers applied greater in-water forces in front crawl (∼61 N) when compared to the low-tier (∼51 N). With SPM, differences were found between 64–74 % and ∼60–90 % of the underwater path of the stroke cycle for the dominant and non-dominant upper limb, respectively. Both upper limbs appear to apply a similar in-water force ($p > 0.05$), regardless of the performance tier. Therefore, swimmers within the same age group differ in the upper limbs applied in-water force during the front crawl. The SPM analysis seems to provide more insights into the applied force during the hand path, as it allows identifying differences according to the underwater phases.

Referência

Santos, C. C., Ruiz-Navarro, J. J., Martinho, D., Ferreira, F. A., Marinho, D. A., & Costa, M. J. (2025). Understanding upper limbs in-water force in young swimmers with Statistical Parametric Mapping analysis. *Journal of Biomechanics*, *189*, 112847. https://doi.org/10.1016/j.jbiomech.2025.112847

30. Relationship Between Dryland Profile and Kinematics of Breaststroke Pullout Techniques

Costa, M.J.[1,2*], Gay, A.[3], Ferreira, F.A.[1], Vilas-Boas, J.P.[1,2], & Santos, C.C.[4,5]

[1] Research Centre for Sports Research, Education, Innovation and Intervention in Sport, CIFI2D, Faculty of Sport, University of Porto, Porto, Portugal
[2] Porto Biomechanics Laboratory, LABIOMEP-UP, University of Porto, Porto, Portugal
[3] Department of Physical Education and Sports, Universidad de Granada, Granada, Spain
[4] Higher Education School, Polytechnic Institute of Coimbra, Coimbra, Portugal
[5] Department of Sport Sciences, Higher Institute of Educational Sciences of the Douro, Penafiel, Portugal

*Corresponding author: mjcosta@fade.up.pt

The aim of this study was twofold: (1) to make a sex comparison on dryland strength, range of motion (ROM), and kinematics of the breaststroke underwater pullout and (2) to analyze the relationship between dryland strength, ROM, and kinematics of different pullout techniques in both male and female swimmers. Sixteen trained swimmers, nine males (20.67±2.71 years old) and seven females (18.86±0.83 years old), performed 3×25 m breaststroke using two pullout breaststroke techniques: Fly-Kick first and Combined. A speedometer and video footage were used to assess the pullout phase kinematics and the total underwater sequence. Dryland assessments included the maximum jump height, the isometric peak strength of internal shoulder rotation (IR) (at 90°), and knee extensors (at 60°). The joint ROM of knee flexion (KF), plantar flexion (PF), and hip internal rotation were also considered. Velocity-time curves of both techniques according to sex were dissected using statistical parametric mapping. An independent t-test was used to compare differences between swimmers' sex in kinematic and dryland variables while the Pearson correlation coefficient (r) was used for associations. Higher instantaneous velocity at ~24–26, ~31–42, and 54.5–63% during the glide phase duration was found for males in the Fly-Kick first technique. Males also displayed a higher peak (3.29 $m \cdot s^{-1}$) and mean velocity (1.58–1.65 $m \cdot s^{-1}$) in the total underwater path or in the glide and propulsion phases of both pullout techniques. While males performed better in jump height (33.89 cm) and peak strength of IR (172–176 N), females showed a higher ROM mostly in PF (161–165°). A high and positive correlation between dryland strength and kinematics in both pullout techniques was found in males. The ROM failed to correlate with pullout kinematics, except for the KF in females during the recovery phase (r=0.82–0.86). In conclusion, male breaststrokers perform better than females on dryland strength but not in joint ROM, which provides them with an advantage mainly in the Fly-Kick first underwater pullout.

Referência

Costa, M. J., Gay, A., Ferreira, F. A., Vilas-Boas, J. P., & Santos, C. C. (2025). Relationship between dryland profile and kinematics of breaststroke pullout techniques. *International Journal of Sports Medicine*, *46*(13), 973–981. https://doi.org/10.1055/a-2625-4264

31. Changes in Biomechanical Profile of an Artistic Swimming Duet over a Training Macrocycle: A Case Study

Costa, M.J.[1,2*], Pinto, S.[1], & Santos, C.C.[3,4]

[1] Centre for Sports Research, Education, Innovation and Intervention in Sport, CIFI2D, Faculty of Sport, University of Porto, Porto, Portugal
[2] Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, Portugal
[3] Department of Sport Sciences, Exercise and Health, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal
[4] Higher Education School, Polytechnic of Coimbra, Coimbra, Portugal

*Corresponding author: mjcosta@fade.up.pt

This study aimed to monitor the biomechanical development of an artistic swimming duet across a macrocycle through an individualised training approach. Two swimmers (17.5 ± 0.5 years), members of the Los Angeles 2028 National Olympic Project, were assessed in December 2023 (M1) and April 2024 (M2), corresponding to the beginning and the end of the macrocycle. Maximal (Fmax) and mean (Fmean) force in the prone sculling and kick pull action were measured using a 20 s tethered test. Split velocity (vSplit) was assessed in free format based on video recording. Dry-land strength included assessments of internal (IR) and external (ER) shoulder rotation strength of the dominant (D) and non-dominant (ND) limbs, and countermovement jump (CMJ) power. The standard duet choreography was analysed in competition at both time points. Percentage variation (Δ%) between swimmers was calculated for M1 vs. M2. Results showed convergence (M1 vs. M2) in Fmean of the sculling (21.6% vs. 9.9%) and kick pull (45.1% vs. 29.1%), accompanied by greater similarity in vSplit (15.9% vs. 15.5%). Further convergence was observed in IR_{ND} (33.7% vs. 13.9%), ER_D (11.6% vs. 4.4%) and CMJ (7.4% vs. 3.6%). The duet's competition score increased from 168.9943 to 190.7183 points. It can be concluded that individualised training was useful for the duet to become more homogeneous in in-water strength, in-water kinematics and dryland strength, resulting in improved competitive performance.

Referência
Costa, M. J., Pinto, S., & Santos, C. C. (2025). Changes in biomechanical profile of an artistic swimming duet over a training macrocycle: A case study. *Applied Sciences*, *15*(19), 10346. https://doi.org/10.3390/app151910346

32. Motivation and intention to remain in swimming training throughout a competitive season: an age-group comparison

Souza, L.[1], Santos, C.C.[2,3], Fernandes, R.J.[1,4], Monteiro, D.[5,6], & Costa, M.J.[1,4*]

[1] Centre for Sports Research, Education, Innovation and Intervention in Sport, CIFI2D, Faculty of Sport, University of Porto, Porto, Portugal
[2] University of Trás-os-Montes and Alto Douro, Vila Real, Portugal
[3] Higher Education School, Polytechnic of Coimbra, Coimbra, Portugal
[4] Porto Biomechanics Laboratory, Porto, Portugal
[5] Research Center in Sport Sciences, Health Sciences and Human Development, CIDESD, Portugal
[6] ESECS -Polytechnic University of Leiria, Leiria, Portugal

*Corresponding author: mjcosta@fade.up.pt

This study aimed to examine variations in motivational regulation and the intention to remain in swimming training across a competitive season, considering different age groups. A total of 154 competitive swimmers participated and were categorised as young, youth, junior and senior. Data were collected at three points during the 2023–2024 season (December, March and June), using the Behavioral Regulation Sport Questionnaire and specific intention items. Results indicated that younger swimmers maintained higher levels of self-determined motivation throughout the season, whereas youth and junior groups experienced greater motivational shifts and a decrease in intention. Interestingly, senior swimmers reported higher levels of controlled motivation, along with increased intention to remain. These findings suggest that both motivation and intention to continue training are age-dependent, emphasizing the importance of age-sensitive strategies to support sustained engagement in competitive swimming.

Referência
Souza, L., Santos, C. C., Fernandes, R. J., Monteiro, D., & Costa, M. J. (2025). Motivation and intention to remain in swimming training throughout a competitive season: An age-group comparison. *Cuadernos de Psicología del Deporte*, *25*(3), 52–66. https://doi.org/10.6018/cpd.668211

33. Factors Relating to Sprint Swimming Performance: A Systematic Review

Ruiz-Navarro, J.J.[1*], Santos, C.C.[2,3], Born, D-P.[4,5,6], López-Belmonte, O.[1], Cuenca-Fernández, F.,[1,7] Sanders, R.[8], & Arellano, R.[1]

[1] Aquatics Lab, Department of Physical Education and Sports, Faculty of Sport Sciences, University of Granada, Granada, Spain
[2] Department of Sport Sciences, Higher Institute of Educational Sciences of the Douro (ISCE-Douro), Penafiel, Portugal
[3] Higher Education School, Polytechnic of Coimbra, Coimbra, Portugal
[4] Section for High-Performance Sports, Swiss Swimming Federation, Bern, Switzerland
[5] Department for Elite Sport, Swiss Federal Institute of Sport Magglingen, Magglingen, Switzerland
[6] Faculty of Science and Medicine, University of Fribourg, Fribourg, Switzerland
[7] Department of Sports and Computer Sciences, Universidad Pablo de Olavide, Seville, Spain
[8] Faculty of Medicine and Health, The University of Sydney, Sydney, Australia

*Corresponding author: jesusruiz@ugr.es

Swimming performance depends on a wide variety of factors; however, the interaction between these factors and their importance varies between events. In sprint events, the characterized pacing underlines its specific development, as swimmers must achieve the highest possible speed while sustaining it to the greatest extent possible. The aim of this review was to identify the key factors underlying sprint swimming performance and to provide in-depth and practical evidence-based information to optimize performance. The review protocol was not registered. PubMed, Web of Science and Scopus databases were searched up to October 31, 2023. Studies involving competitive swimmers and investigating sprint swimming performance were included, while studies conducted with young or masters' swimmers, triathletes or water polo players or not investigating sprint swimming performance were excluded. The Downs and Black Quality Assessment Checklist was performed on the included articles to assess the methodological quality. After applying the PICOS framework, 39 of the 1330 articles initially identified were included according to the PRISMA guidelines. The included records focused mainly on dry-land strength and in-water forces of both upper and lower limbs. A wide range of kinematic variables were also examined, together with the importance of anthropometric and various physiological parameters. This review highlights the importance of developing muscular strength and effectively transferring it to performance in the water. The evidence suggests that muscular development should prioritize enhancing velocity and effective displacement, rather than merely increasing force and performance in loaded tests. However, further research is needed to confirm this. While in-water forces have been well studied, there is a notable lack of analysis regarding drag. The optimal balance between stroke rate and stroke length should be determined individually, with a primary focus on achieving a high stroke length from a high stroke rate. Although anthropometry may play an important role in performance, the interaction of these traits appears to be complex, suggesting that other factors may be more important in determining performance outcomes. From a physiological perspective, the results indicate that the lactate peak and rate of accumulation should be thoroughly developed. Notwithstanding, this review shows the lack of a solid body of knowledge on the importance of anaerobic and especially aerobic factors. Finally, the absence of a list of potential confounders, together with the lack of high-quality studies involving elite swimmers (level 1 and 2), complicates the interpretation of the results.

Referência

Ruiz-Navarro, J. J., Santos, C. C., Born, D.-P., López-Belmonte, Ó., Cuenca-Fernández, F., Sanders, R. H., & Arellano, R. (2025). Factors relating to sprint swimming performance: A systematic review. *Sports Medicine*, *55*(4), 899–922. https://doi.org/10.1007/s40279-024-02172-4

RESUMOS EM ATAS DE CONFERÊNCIA

RESUMOS EM ATAS DE CONFERÊNCIA

Caracterização geral da produção científica

A produção científica reunida neste capítulo integra 37 resumos publicados em atas de conferência (Tabela 2). A análise quantitativa evidencia uma clara predominância da área temática de Treino Desportivo e Performance (Figura 3), reunindo 28 resumos. Esta distribuição decorrente, em parte, dos artigos publicados em revistas, revela que a investigação científica direciona fortemente o seu interesse para a área do treino com foco nos domínios da biomecânica, fisiologia, avaliação e controlo do treino e fatores associados à performance em Natação Pura Desportiva, Polo aquático e Natação Artística. Embora esta tendência tenha vindo a ser revertida na última década, as restantes áreas temáticas ainda carecem de atratividade para produção científica. As áreas de Ensino da Natação e suas vertentes, e de Fitness e Terapia Aquática, apresentam uma expressão quantitativa mais reduzida apresentando 5 e 4 resumos, respetivamente. Já a área de Direção Técnica e Gestão de Piscinas não apresentou resumos identificados na produção analisada, o que revela uma necessidade urgente para os próximos anos.

Tabela 2. Identificação e distribuição da produção científica em formato de resumo pelas áreas temáticas em análise.

Área temática	ID
Treino Desportivo e Performance	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 25, 26, 27, 28, 30, 31, 32, 33, 34, 37
Ensino da Natação e suas vertentes	20, 21, 22, 29, 35
Fitness e Terapia Aquática	17, 23, 24, 36
Direção Técnica e Gestão de Piscinas	N/A

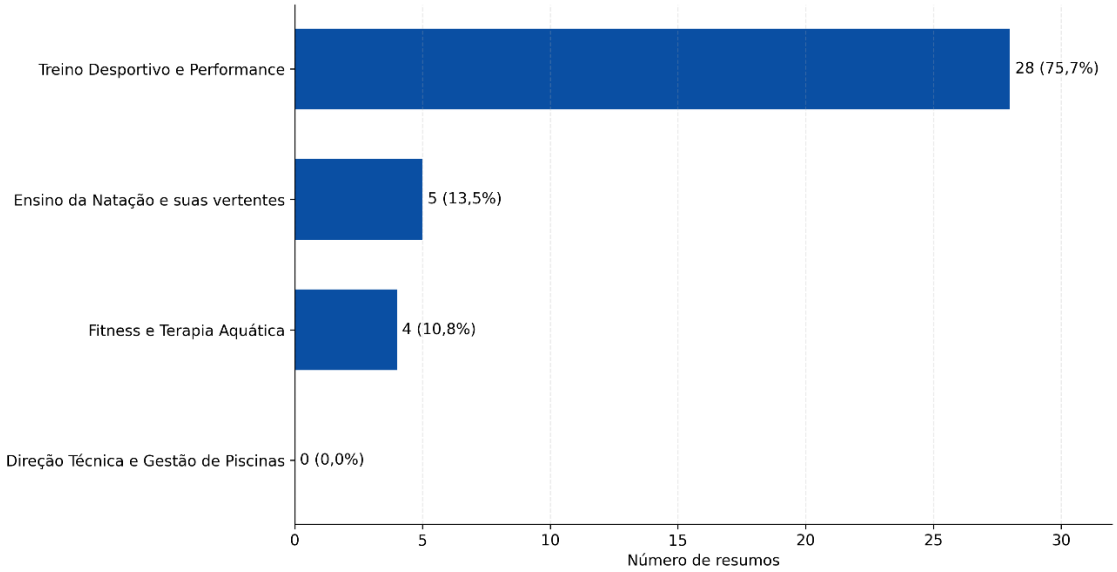


Figura 3. Distribuição percentual dos resumos publicados em atas de conferência por área temática (n = 37).

A Figura 4 revela a participação diferenciada dos investigadores no conjunto de resumos analisados, com alguns autores a assumirem maior presença na produção científica ao longo do ano em análise.

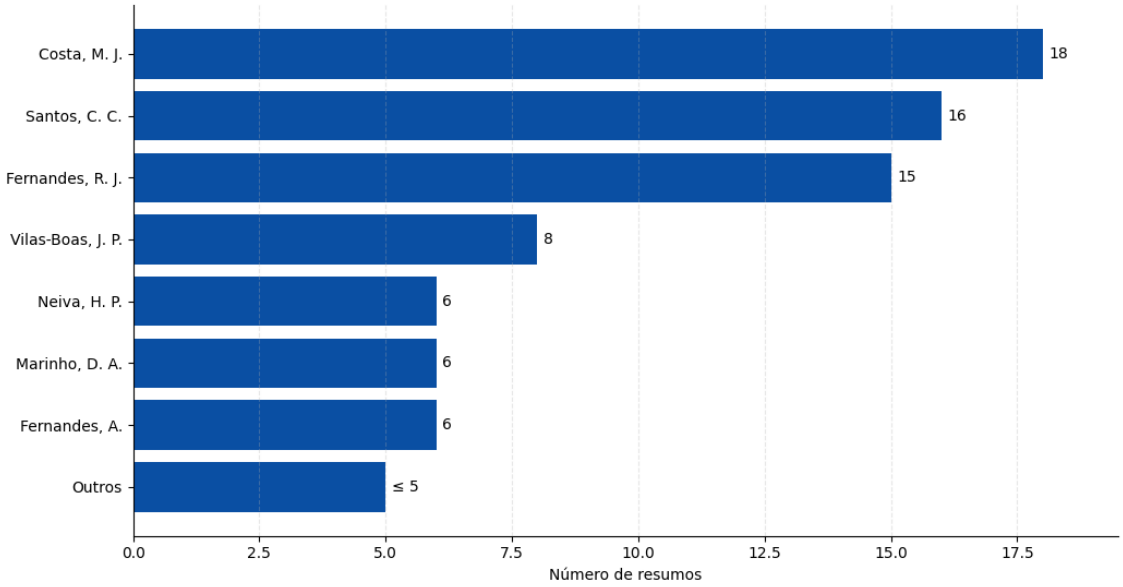


Figura 4. Identificação dos autores com maior número de resumos publicados em atas científicas no âmbito das atividades aquáticas.

1. Análise cinemática de ciclos inspiratórios e não inspiratórios na técnica de mariposa à intensidade máxima

Borda, I.[1], Pimentel, M.[1], Cardoso, A.[1], Cardoso, R.[1], Sampaio, A.[1], Carvalho, D.D.[1], Fernandes, A.[1], & Fernandes, R.J.[1]

[1] Centro de Investigação, Formação, Inovação e Intervenção em Desporto e Laboratório de Biomecânica do Porto, Faculdade de Desporto, Universidade do Porto, Porto, Portugal

*autor correspondente: N/A

Uma das tarefas inerentes ao dia a dia dos treinadores de natação é a capacidade de instruírem os nadadores para a sua melhor técnica procurando o desenvolvimento de competências e a melhoria do desempenho. Os efeitos da respiração na técnica de mariposa já foram estudados em relação à coordenação em distâncias mais longas [1], mas ainda não se conhece como a respiração poderá influenciar o desempenho de um nadador em distâncias curtas. O presente estudo teve como objetivo comparar variáveis cinemáticas de ciclos não inspiratórios e inspiratórios durante 25m à máxima intensidade. Seis nadadores do sexo feminino (15.4±0.9 anos, 167.5±3.0 cm de altura, 59.7±3.6 kg de peso e 686±75 pontos World Aquatics, nível 3) e 3 nadadores do sexo masculino (17.3±0.6 anos, 178.7±7.6 cm de altura, 72.1±9.7 kg de peso e 683±67 pontos World Aquatics, nível 3) realizaram 25m mariposa em intensidade máxima, sendo registados por uma câmara subaquática em movimento (120 Hz, Go Pro 7) no plano sagital [2]. A análise foi realizada em dois ciclos consecutivos (não inspiratório e inspiratório) analisando as velocidades média, máxima e mínima e a variação da velocidade intracíclica (através do coeficiente de variação), bem como a duração relativa das fases do ciclo dos membros superiores (ação lateral exterior, ação lateral interior, ação ascendente e recuperação) e o momento das ações descendentes dos membros inferiores. Treze e sete pares de ciclos inspiratórios e não inspiratórios dos nadadores do sexo feminino e masculino (respetivamente) foram comparados com um teste t de medidas repetidas, utilizando o SPSS. A velocidade média inspiratória e não inspiratória foi também analisada com statistical parametric mapping para nadadores do sexo feminino e masculino ($p < 0,05$). Os ciclos inspiratórios das nadadoras apresentaram velocidades médias, máximas e mínimas mais elevadas que os não inspiratórios, tal como com os nadadores relativamente às velocidades médias e mínimas (Tabela 1). A variação intracíclica da velocidade não mostrou diferenças entre os ciclos não inspiratórios e inspiratórios em ambos os grupos. As nadadoras apresentaram uma maior duração da ação lateral exterior e uma recuperação mais curta durante os ciclos inspiratórios, enquanto os nadadores mantiveram a duração relativa das fases entre ciclos. Ambos os grupos realizaram as ações dos membros inferiores em momentos semelhante do ciclo, com a 1ª ação durante a ação lateral exterior e a 2ª durante a fase de recuperação. O SPM demonstra que a curva de velocidade dos ciclos inspiratório não inspiratório são similares (Figura 1).

Tabela 1. Média ± DP das variáveis cinemáticas da técnica de mariposa à intensidade máxima.

Variáveis	Feminino			Masculino		
	Não inspiratório	Inspiratório	p	Não inspiratório	Inspiratório	p
Velocidade média (m/s)	1.57 ± 0.07	1.54 ± 0.06	0.002	1.82 ± 0.05	1.76 ± 0.05	0.001
Velocidade máxima (m/s)	2.06 ± 0.18	2.02 ± 0.12	0.223	2.55 ± 0.17	2.45 ± 0.18	0.088
Velocidade mínima (m/s)	1.09 ± 0.18	1.02 ± 0.28	0.109	1.24 ± 0.15	1.14 ± 0.09	0.021
Variação intracíclica da velocidade (%)	17.9 ± 5.3	18.3 ± 5.7	0.570	19.4 ± 3.7	20.7 ± 4.8	0.381

Ação lateral exterior (%)	24.8 ± 4.7	26.2 ± 4.6	0.014	23.9 ± 2.9	23.8 ± 3.4	0.930
Ação lateral interior (%)	21.1 ± 3.1	22.1 ± 1.6	0.245	23.7 ± 1.0	25.1 ± 3.9	0.393
Ação ascendente (%)	17.1 ± 2.6	16.2 ± 2.4	0.166	17.2 ± 1.6	17.4 ± 1.3	0.712
Recuperação (%)	37.1 ± 2.5	35.5 ± 2.8	0.026	35.2 ± 3.3	33.7 ± 2.8	0.126
1ª ação descendente dos membros inferiores (%)	12.5 ± 3.4	12.3 ± 2.3	0.709	12.9 ± 6.0	13.3 ± 5.8	0.674
2ª ação descendente dos membros inferiores (%)	69.1 ± 1.2	70.0 ± 2.1	0.117	65.6 ± 4.5	67.1 ± 4.2	0.199

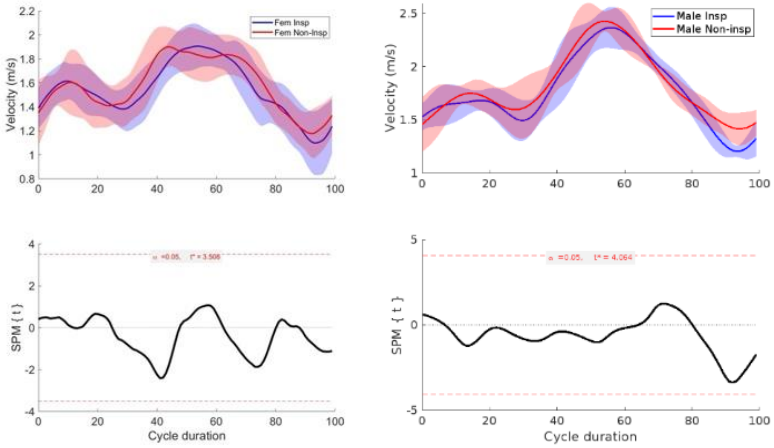


Figura 1. Statistical Parametric Mapping da velocidade média dos ciclos inspiratórios e não inspiratórios nos nadadores do sexo feminino e masculino, painéis esquerdo e direito, respetivamente.

Os ciclos inspiratórios de todos os nadadores foram mais lentos do que os ciclos não inspiratórios, indicando que a proporção dos ciclos inspiratórios numa prova máxima deve ser controlada [1]. No entanto, a variação intracíclica da velocidade foi semelhante, mantendo a eficiência. A maior duração da ação lateral exterior e recuperação mais rápida durante o ciclo inspiratório das nadadoras, podem estar relacionadas com o tempo necessário para levantar a cabeça, minimizando a recuperação para compensar um possível atraso. Já os nadadores mantiveram a duração relativa das fases dos membros superiores, o que sugere que estão mais familiarizados com a compensação do tempo gasto na ação de cada membro. O momento das ações dos membros inferiores também não se alterou entre ciclos em ambos os grupos. Conclusão: Em provas rápidas de mariposa, os nadadores e treinadores devem ser cuidadosos relativamente à frequência inspiratória dos seus atletas, uma vez que esta pode levar a performances mais lentas. A manutenção da duração relativa das fases do ciclo pode ser um fator estratégico para evitar quedas de velocidade.

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2. Evaluation of the front crawl technique: comparative acceleration analysis between two different paces, using inertial measurement units (IMU)

Santos, P.[1*], Gomes, B.[1,2], Fernandes, R.J.[3], & Rama, L.[1,2]

[1] Faculty of Sport Sciences and Physical Education, University of Coimbra, Coimbra, Portugal
[2] Interdisciplinary Centre for the Study of Human Performance (CIPER), University of Lisbon, Cruz-Quebrada, Lisbon, Portugal
[3] CIFI2D and LABIOMEP, FADEUP, University of Porto, Porto, Portugal

*Corresponding author: panrisantos@hotmail.com

Incorporating IMU in swimming enables near real-time kinematic analysis, assessing stroke-generated acceleration along all three axes. This approach provides coaches with prompt, valuable feedback during practice, allowing rapid evaluation of each swimmer's technique and performance, an advantage over traditional video analysis or stopwatches. Moreover, AI advancements enhance the ability to find individual swimming patterns, offering significant information without overwhelming coaches. This pilot study explored swimming dynamics at different paces in sprinters and long-distance swimmers, analysing their acceleration pattern. Six swimmers (four boys (B) and two girls (G), 14.15±0.79-year-old) were divided into two groups: three sprinters (BS1, BS2, BS3) and three long-distance swimmers (GL1, BL2, GL3). All participants had consent for free and informed participation signed by responsible caretakers. They performed 2x (3x50 m) front crawl, the first series at a maximal pace (1:5 of work/rest time), and the second at a 1500 m pace (1:1 of work/rest time). Between series, they actively recovered for 200 m plus 3 min. Swimmers wore a belt designed by Janga® in thin and light neoprene, ensuring that it did not alter their natural movements and caused negligible drag, with the IMU (Wimu Pro Device, WIMU®) positioned next to L5. The first two repetitions were considered adaptation, and the last was recorded and analysed. For data confirmation, a video analysis on Kinovea® software was performed. Acceleration was analysed with a MATLAB® routine, providing speed (AS), stroke rate (SR), peak acceleration per stroke (PA) and percentage peak difference between 0-25 and 25-50 m (PD). The two series were compared based on SR, PA, and PD using the Wilcoxon test, conducted in SPSS. The results are presented in Table 1. Athletes showed higher SR in maximal series, as expected, and statistical differences were found (ρ=0.01). PA was generally higher in the maximal pace, with significant differences (ρ=0.01). PD was closer to 0 at the 1500 m pace, but deviated more at maximal pace due to fatigue, without statistical significance. In conclusion, this analysis can provide coaches with essential data to better understand athlete performance and progression over a season. Future studies should expand the range of paces and include a larger sample to refine the analysis and better quantify the differences. These findings can help coaches understand the impact of different paces on stroke rate and acceleration, and how to adjust training strategies accordingly.

Table 1. Comparison between maximal and 1500 m pace series.

S	First series (maximal pace)						PD (%)
	0-25 m			25-50 m			
	AS ($m \cdot s^{-1}$)	SR (CPM)	PA ($m \cdot s^{-2}$)	AS ($m \cdot s^{-1}$)	SR (CPM)	PA ($m \cdot s^{-2}$)	
BS1	1.96	50.32	1.83	1.77	46.55	1.62	11.21
BS2	2.21	60.01	1.46	1.97	53.51	1.46	-0.09
BS3	2.03	49.74	1.14	1.69	47.51	1.01	11.34
GL1	1.81	50.70	1.01	1.57	49.40	0.93	8.26
BL2	1.88	47.98	1.32	1.78	47.24	1.32	-0.08
GL3	1.78	52.88	1.20	1.60	49.28	1.16	3.61
Avg ± std	1.95±0.13	51.94±3.60*	1.33±0.25*	1.73±0.12	48.92±2.13*	1.25±0.22*	5.71±4.47
S	Second series (1500 m pace)						PD (%)
	0-25 m			25-50 m			
	AS ($m \cdot s^{-1}$)	SR (CPM)	PA ($m \cdot s^{-2}$)	AS ($m \cdot s^{-1}$)	SR (CPM)	PA ($m \cdot s^{-2}$)	
BS1	1.51	34.98	1.47	1.52	35.43	1.45	1.31
BS2	1.62	39.18	1.35	1.56	40.40	1.35	0.17
BS3	1.58	30.98	1.10	1.40	29.18	1.30	-17.40
GL1	1.51	40.47	0.96	1.40	40.79	0.96	0.03
BL2	1.61	39.35	1.13	1.47	39.31	1.13	0.54
GL3	1.54	37.91	1.17	1.37	35.79	1.20	2.56
Avg ± std	1.56±0.04	37.15±3.25*	1.20±0.17*	1.45±0.07	36.82±4.00*	1.23±0.16*	-2.13±6.68

* -The pairs have statistically significant differences between max and 1500 m pace (ρ=0.05).

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3. Lateral preference and proficiency in master swimmers

Felix M.[1], Correia S.[1], Fernandes R.[2], Soares S.[2], Fernandes A.[2], Pacheco M.[2], & Vasconcelos O.[2]

[1] Faculty of Sport, University of Porto, Porto, Portugal
[2] CIFI2D, Faculty of Sport, University of Porto, Porto, Portugal

*Corresponding author: N/A

Human movement is characterized by limb asymmetries [1] categorized in lateral preference (limb selection based on past experiences) and proficiency (functional superiority of a limb in motor execution). Swimming is a cyclic sport, demanding a balanced action between the limbs, but the relation between lateral preference and swimming motion seems to be unclear. This study aims to analyse the relationship between lateral preference and upper limbs dominance, and its influence on motor performance. Eighteen male and female master swimmers (41.77±13.15 years) performed a handgrip strength test using a calibrated dynamometer (Takei model 5101 TKK), a motor coordination Minnesota manual dexterity test and a 30-second all-out tethered front-crawl swimming test with an electromechanical isokinetic resistance device (Swim Spektro, Talamonti Spa, Italy). Handgrip strength revealed that 16.7% of the swimmers' habitual limb usage does not necessarily correspond to superior strength ability. In the dexterity test, 22.2% showed an inversion of dominance, indicating that fine motor tasks requiring coordination and rapid adjustments promote greater engagement of the non-preferred limb. Lastly, 27.8% presented as upper limbs force asymmetry when performing maximal front crawl, emphasizing that complex, cyclic and multi-segmental tasks in aquatic environments challenge fixed laterality patterns. Difference across tasks suggests that motor proficiency is highly dependent on the functional and environmental demands of each activity rather than a static characteristic. It was observed a progressive increase in the dissociation between lateral preference and dominance as task complexity intensifies, reinforcing the need to consider task specificity in laterality assessments and suggesting that lateral dominance is modifiable through motor experiences (particularly in high-demand sport-specific contexts).

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4. Intracycle velocity variation in swimming

Fernandes, A.[1], Mezêncio, B.[2], Vilas-Boas, J.P.[1], & Fernandes, R.J.[1]

[1] Centre of Research, Education, Innovation and Intervention in Sport, Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Portugal
[2] Biomechanics Laboratory, School of Physical Education and Sport, University of São Paulo, Brazil

*Corresponding author: N/A

Swimming performance is determined by multiple factors, with biomechanics providing direct and measurable opportunities for improvement. Swimming gestures are cyclic, yet the alternation between propulsive and resistive phases produces fluctuations in acceleration and velocity [1]. These intracycle variations represent energy losses, as swimming efficiency is maximized when mean velocity is maintained as constant as possible [2]. While velocity stability has long been linked to mechanical efficiency, there is still a need to refine the metrics used to describe and interpret these variations in a performance context. Intracycle velocity variation has been assessed using different techniques, including speedometers, video analysis and inertial sensor-based systems. The coefficient of variation remains the most common index, although alternative approaches have been suggested. These include maximum–minimum velocity differences, velocity ratios normalized to the mean and more advanced techniques such as statistical parametric mapping or non-linear models. All methods aim to quantify velocity oscillations within a swimming cycle and to link them with efficiency and performance outcomes. Although the coefficient of variation is sensitive to velocity dispersion, it does not clearly distinguish competitive levels or pacing strategies. This limitation becomes evident under conditions of high hydrodynamic drag, where greater mechanical power is required to overcome resistive forces. Since part of this power is inevitably lost to velocity fluctuation, conventional indices provide only partial insight. The relative power to velocity variation has been proposed as an alternative, integrating individual hydrodynamic characteristics and partitioning total power into the components used to overcome drag and those dissipated in oscillations. Among swimming techniques, breaststroke is the most mechanically demanding, followed by butterfly, backstroke and front-crawl. Traditional quantification methods often disregard the mechanical basis of swimming motion. By contrast, the relative power to velocity variation offers a more comprehensive perspective, capturing the energetic cost of velocity instability and its effect on efficiency. This measure enhances understanding of the biomechanical determinants of performance and provides practical implications for technical refinement and monitoring.

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5. Analysing front crawl using the Froude number

Fernandes, A.[1], Borda, I.[1], Mezêncio, B.[2], Vilas-Boas, J.P.[1], & Fernandes, R.J.[1]

[1] Centre of Research, Education, Innovation and Intervention in Sport, Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Portugal
[2] Biomechanics Laboratory, School of Physical Education and Sport, University of São Paulo, Brazil

*Corresponding author: N/A

Wave drag opposed to a swimming body is dependent on the ratio of its velocity and the length of the water wave made by the swimmer's displacement. The Froude number is a dimensionless index that accounts for the interaction of inertia and gravitational forces, based on the swimmer's velocity and body height, and is commonly used to evaluate the wave-making resistance [1]. Investigating the Froude number at controlled paces can provide insight into the drag regime between swimmers. Ten regional and twelve elite male swimmers (24 ± 4 vs. 19 ± 3 years old, 73 ± 6 vs. 71 ± 7 kg of body mass, 1.8 ± 0.1 vs. 2.0 ± 0.0 m of height and 490 ± 58 vs. 702 ± 78 WA points) performed 25 m front crawl at maximal intensity. Swimmers were video recorded in the sagittal plane with an underwater camera (GoPro, California, USA) that followed their displacement along the swimming pool. Swimming velocity was obtained through video analysis and the Froude number was calculated as the ratio between mean swimming velocity and the square root of the product of gravitational acceleration and body height. Swimmers with different body height can present similar Froude numbers even at different mean velocities (e.g., S3 and S8), as this index reflects the wave drag generation, meaning that although S8 swims faster, both swimmers face a comparable drag regime. When comparing at the same mean velocity, taller swimmers show lower Froude numbers, since their greater body height reduces the velocity relative effect on drag. For instance, S19 compared to S18 operates in a more demanding regime relative to body height, which implies higher locomotion effort. Figure 1. Froude number as a function of mean velocity, with body length (black dots) as reference. This approach highlights inter-individual differences that are not captured by velocity alone and may help technical assessment in both research and coaching contexts.

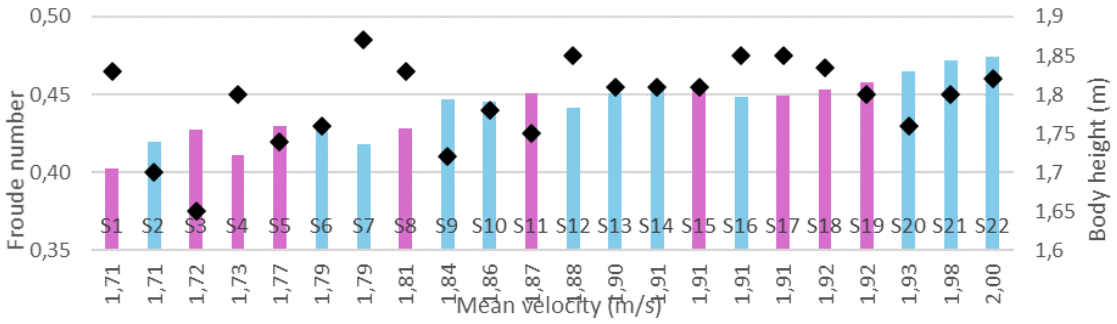


Figure 1. Froude number as a function of mean velocity, with body length (black dots) as reference.

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6. Butterfly kinematic adaptations across swimming paces

Borda, I.[1], Fernandes, A.[1], & Fernandes, R. J.[1]

[1] Centre of Research, Education, Innovation and Intervention in Sport and Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, Portugal

*Corresponding author: N/A

Butterfly is one of the most demanding swimming techniques, requiring refined motor skills to balance propulsive and resistive forces [1]. Swimmers of different competitive levels typically perform multiple races, being required to manage pacing strategies at varying intensities. Consequently, kinematic adjustments should be implemented to meet the specific race demands [2]. The current study aimed to compare kinematic patterns across increasing swimming paces, providing a more detailed characterization of technical and energetic demands of this specific swimming technique. Ten swimmers (4 females and 6 males: 25 ± 6 and 24 ± 5 years old, 61 ± 6 and 76 ± 5 kg of body mass, 169 ± 5 and 181 ± 4 cm of height and 448 ± 73 and 590 ± 52 World Aquatics points in short course 100 m butterfly event, respectively) performed 25 m butterfly trials at 88, 93 and 100% of maximal intensity. Submaximal velocities were controlled using flashing lights (Pacer2Swim; KulzerTEC, Aveiro, Portugal) and performances were recorded using an underwater camera (Go Pro 7, California, USA). Mean velocity, stroke index, stroke rate and length, intracycle velocity variation (IVV) and upper-limb phases relative duration were calculated and compared between paces with a repeated measures ANOVA (SPSS), followed by a post hoc Bonferroni test ($\alpha = 0.05$). Female swimmers mean velocity (1.28 ± 0.10, 1.38 ± 0.14 and 1.44 ± 0.09 m/s; $p < 0.05$ for v88 vs. v93 and v88 vs. v100) and stroke rate (44 ± 2, 51 ± 6 and 56 ± 4 cycles/min; $p < 0.05$ for v88 vs. v100) increased with pace, while stroke length decreased (1.8 ± 0.1, 1.6 ± 0.1 and 1.5 ± 0.1 m; $p < 0.05$ for v88 vs. v100 and v93 vs. v100). Stroke index remained stable while IVV (20 ± 4, 14 ± 5 and 17 ± 4%; $p < 0.05$ for v88 vs. v100) and non-propulsive phase duration (64 ± 4, 62 ± 4, 58 ± 4%; $p < 0.05$ for 88 vs.93) decreased with intensity. Male swimmers mean velocity (1.57 ± 0.09, 1.65 ± 0.09, 1.75 ± 0.09 m/s; $p < 0.05$) and stroke rate (45 ± 3, 50 ± 2, 59 ± 3 cycles/min; $p < 0.05$) increased with pace, while stroke length decreased (2.1 ± 0.2, 2.0 ± 0.2, 1.8 ± 0.2 m; $p < 0.05$ for v88 vs. v100 and v93 vs. v100). Stroke index and IVV did not differ, whereas the propulsive phase duration increased with intensity (35 ± 2, 36 ± 3, 38 ± 3%; $p < 0.05$ for all comparisons). Swimmers increased velocity across paces mainly by adjusting stroke rate, stroke length and propulsive and non-propulsive phases duration. Technical efficiency is generally maintained at submaximal paces, but it tends to change at maximal intensity. These findings highlight the need for coaches to design training that develops both technical stability and adaptability at different intensities.

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7. Measurement of propulsive forces and passive and active drag in Olympic and national-level swimmers: a pilot study

Lemos, I.[1], Machado, L.[1,2,3], Fonseca, P.[1,3], Fernandes, R. J.[1,2,3], Soares, S.[1,2,3], & Vilas-Boas, J. P.[1,2,3]

[1] Faculty of Sport, University of Porto, Porto, Portugal
[2] CIFI2D, Faculty of Sport, University of Porto, Porto, Portugal
[3] LABIOMEP, Faculty of Sport, University of Porto, Porto, Portugal

*Corresponding author: N/A

A swimmer's performance is a direct consequence of the combination of propulsive force (F_p) and hydrodynamic drag, which vary depending on gender and athletic level [1]. Studying these factors can help adjust training loads and enhance performance, while quantifying the differences between swimmers of different athletic levels can indicate which kinetic variables should be prioritized for optimization. Two Olympic- and national-level swimmers, specializing in different swimming techniques, performed a 25 m front crawl sprint to determine their average speed and stroke rate. Propulsive force (F_p) in front crawl was measured in a tethered swim, and active drag (D_a) in a semi-tethered swim (at 10% of maximum propulsive force), using the method of Haskins et al. [2]. Both tests were conducted with the same duration and stroke frequency as the sprint. To determine passive drag (D_p), the swimmers were towed over 25 m in a hydrodynamic position at their sprint average speed. All tests were carried out using a force measurement cable system (Swim Spektro, Talamonti Spa, Italy). Results showed that Olympic swimmers produce higher values of F_p (♂ = 12.2%; ♀ = 28.8%), D_a (♂ = 14.0%; ♀ = 33.8%) and D_p (♂ = 5.9%; ♀ = 10.9%), which are associated with higher swimming speeds and lower coefficients of variation (CV). F_p in streamlined swimming, and its CV, contribute most to differentiating swimmers of different levels. Olympic swimmers exhibit higher F_p and lower CV, reflecting their ability to sustain greater propulsive forces with fewer fluctuations. In contrast, variables related to D_a and D_p appear less informative, since they are particularly sensitive to the speed at which they are measured. An exception is the variability of D_p, which, being lower, highlights the superior ability of Olympic swimmers to maintain a stable hydrodynamic position. Data suggest that training should focus on enhancing hydrodynamic efficiency (by increasing F_p and reducing D_a), minimizing F_p variability and improving control of the hydrodynamic position. Metronomes pacing and tethered swimming tests can provide valuable information for routine training.

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8. Does fatigue have a significant impact on peak stroke acceleration during 400 m distance? An exploratory study

Santos, P.[1], Gomes, B.[1,2], Fernandes, R.J.[3], & Rama, L.[1,2]

[1] Faculty of Sport Sciences and Physical Education, University of Coimbra, Portugal
[2] CIPER, University of Lisbon, Portugal
[3] CIFI2D and LABIOMEP, FADEUP, University of Porto, Portugal

*Corresponding author: N/A

The incorporation of inertial measurement units (IMUs) during swimming allows for near-real-time kinematic analysis of the swimmer, making possible to assess the acceleration generated by the movement and analyse it [1]. Researchers can then explore different key variables for performance enhancing. This exploratory study focused on the effects of fatigue on stroke rate and peak acceleration during 400-meter distance at maximal pace at front crawl. Four male athletes (15.3 ± 1.4 years old, 433.3 ± 60.9 FINA Points) preformed 400 m front crawl at a pace between 95% and 100% of their best result at the distance. Participants wore a specially designed belt, developed by Janga® that did not impede or alter their natural swimming movements. The IMU (WIMU Pro Device) was placed in a belt pocket aligned with L5. To analyse the data collected by the IMU, a MATLAB® routine was developed to identify acceleration peaks in meters per second squared (AP ($m \cdot s^{-2}$)) and stroke rate in cycles per minute (SR (cpm)) and their correlations with lap time in seconds (t (s)), using a linear regression (R^2). The following table 1 shows a resume of each athlete during each 50m lap t, SR and AP.

Table 1. Results obtained using MATLAB® routine for t (s), SR (cpm) and AP ($m \cdot s^{-2}$) and their correlation with t, showed as R^2, for the four athletes (ATH)

ATH		0-50	50-100	100-150	150-200	200-250	250-300	300-350	350-400	Average	R^2
1	t	39.20	40.70	40.80	40.58	40.78	41.95	42.10	41.20	40.91	-
	SR	40.07	37.95	38.90	38.63	39.53	39.22	39.44	38.59	39.04	0.04
	AP	10.15	9.83	9.63	9.74	9.82	9.64	9.54	9.72	9.76	0.82
2	t	38.96	41.66	44.00	41.92	43.71	39.98	42.08	40.31	41.58	-
	SR	41.17	35.69	36.05	37.78	37.97	38.55	37.02	36.37	37.57	0.34
	AP	9.89	10.09	9.83	9.93	10.41	10.78	10.05	10.01	10.12	0.02
3	t	40.11	39.02	38.91	39.21	39.47	39.54	39.82	39.14	39.40	-
	SR	32.89	33.26	32.22	32.64	35.00	33.41	33.68	32.27	33.17	0.13
	AP	10.91	10.50	10.94	10.50	10.51	11.06	10.60	11.36	10.80	0.00
4	t	41.00	48.83	47.85	47.98	48.71	48.14	48.21	47.69	47.30	-
	SR	44.15	38.16	38.22	37.77	37.64	37.88	37.27	36.11	38.40	0.86
	AP	10.55	10.55	10.42	10.75	10.64	10.61	10.43	10.14	10.51	0.00

SR showed a higher relation on all athletes, as expected. Increased t due to fatigue had no relation with the variation observed on AP, except on athlete 1, with a strong relation (0.82). The analyses performed in this study showed no consistent results due to the low number of subjects. The effects of fatigue during the 400 m on SR and AP are therefore not proved.

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9. The use of inertial measurement units for swimming practice control: A pilot study

Santos, P.[1,2*], Gomes, B.[1,2], Fernandes, R.[3], & Rama, L.[1,2]

[1] University of Coimbra, FCDEFUC, Coimbra, Portugal
[2] University of Coimbra, CIPER, Coimbra, Portugal
[3] University of Porto, FADEUP, Porto, Portugal

*Corresponding author: panrisantos@hotmail.com

Incorporating inertial measurement units (IMUs) in swimming has the potential to enable a kinematic analysis of the swimmer in near real-time. Their use allows the evaluation of acceleration generated by stroke movements in all three axes [1], allowing coaches to provide timely and valuable feedback during practice. This pilot study aims to demonstrate the effectiveness of these devices for training control in swimming, enabling quick and efficient assessments of each swimmer's individual technique and performance - unlike traditional video analysis, which can be considerably timeconsuming, or relying on a stopwatch when a coach is managing many swimmers simultaneously. Moreover, advancements in AI technology enhance the ability to identify each athlete's swimming pattern besides identifying lap times, turns and strokes. This provides significant information to coaches, without overwhelming them with tasks. The pilot study evaluated 9 swimmers, 4 male and 5 female (age: 13.78±0.76-year-old) with at least three years of competitive swimming experience. Free written consent was obtained from participants' caretakers on a consent form previously approved by the Ethical Committee. Each of them did a task of 3x 50 m front crawl at max speed, with a rest time of 5 to 1 of work time. During each repetition, swimmers wore a specially designed neoprene belt developed by Janga®, which did not limit or alter their natural swimming movements. The IMU (Wimu Pro Device, WIMU®) was placed on the belt, and positioned next to L5. The first two repetitions of 50 m were considered adaptations. To analyze the data collected by the IMU, namely the acceleration in the Y axis (longitudinal to swimming) and total acceleration, a routine was developed in MATLAB® with an algorithm for automatic detection of the 25 m lap time, number of strokes, stroke rate, acceleration peaks and turning duration. For comparison, the 50 m were recorded. Lap time, number of stroke cycles and stroke rate at each 25 m were collected by video analyses on Kinovea software [2]. The data is shown as mean ± standard deviation for each 25 m of lap time in seconds (LT (s)), number of strokes (N), stroke rate in cycles per minute (SR (CPM), turn time in seconds (TT (s)) and stroke cycle peak acceleration in meters per second squared (PA (m.s-2). The results are presented for both data collection methods: video analyses (VA) and MATLAB routine (MR). Statistical analyses using Bland Altman and Wilcoxon tests were performed, using ρ=0.05. Table 1 presents the data collected with both methods for all athletes. The difference between averages (Diff) is presented. Values marked with * have statistically significant differences (ρ=0.05). As seen by the comparison in Table 1, the values of LT, N and SR collected are not statistically different. As that, the accelerometry data can be successfully used for practice control, helping coaches controlling a large group of swimmers. Although being a significant conclusion, it is important to test this method more extensively with other swimming paces, distances and more athletes.

Table 1. Comparison between both collection methods for all athletes.

Data	Lap	0-25	25-50
LT (s)	SW	16.44±1.06	16.86±1.05
	MR	16.21±1.21	16.84±1.21
	Diff	0.23	0.02
N	SW	21.33±1.76	23.44±1.50
	MR	21.33±1.76	23.44±1.50
	Diff	0	0
SR (CMP)	SW	51.76±4.53	48.49±3.79
	MR	51.40±4.38	48.81±3.75
	Diff	0.36	-0.32
TT (s)	SW	2.62±0.15	
	MR	2.41±0.59	
	Diff	0.21*	
PA ($m \cdot s^{-2}$)	MR	1.12±0.39	1.07±0.39

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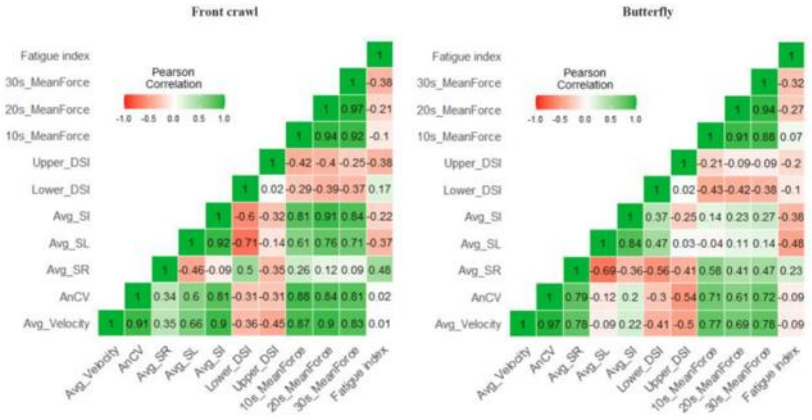
10. Does the dynamic strength index, tethering force, and anaerobic critical velocity significantly influence front crawl and butterfly swimming

Matjiur, R.[1], Chainok, P.[1*], Limroongreungrat, W.[2], Lauer, J.[3,4], de Jesus, K.[5], Zacca, R.[6,7], Fernandes, R. J.[8], & Vilas-Boas, J. P.[8]

[1] Faculty of Sport Science, Burapha University, Thailand
[2] College of Sport Science and Technology, Mahidol University, Thailand
[3] Brain Mind Institute, School of Life Sciences, Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland
[4] Rowland Institute at Harvard, Harvard University, Cambridge, MA, USA
[5] Human Performance Laboratory, Faculty of Physical Education and Physiotherapy, Federal University of Amazonas, Brazil
[6] Research Center in Physical Activity, Health and Leisure (CIAFEL), Faculty of Sports, University of Porto (FADEUP), Porto, Portugal
[7] Laboratory for Integrative and Translational Research in Population Health (ITR), Porto, Portugal
[8] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D) and Porto Biomechanics Laboratory (LABIOMEP-UP), Faculty of Sport, University of Porto, Porto, Portugal

*Corresponding author: phornpot@go.buu.ac.th

A multivariate analysis approach in swimming performance can help to examine the complex interplay between multiple biomechanical and physiological factors, allowing to better understand how different variables contribute to sprint swimming success [3]. Particularly, analyzing neuromuscular performance using upper and lower dynamic strength index (DSI), tethered force and anaerobic critical velocity (AnCV) together could provide a comprehensive evaluation of an age-group swimmers' ability to generate speed in 50 m maximum exertion front crawl and butterfly events. Fourteen regional age-group swimmers (age: 13.3 ± 0.1 years; height: 1.67 ± 0.1 m; mass 56.0 ± 9.4 kg; maturity offset: -1.82 ± 0.8 years; and 420 ± 88 vs. 388 ± 84 of front crawl and butterfly World Aquatics points) performed countermovement jumps and isometric mid-thigh pull (IMTP), as well as ballistic push-up and isometric grip strength, to determine lower and upper extremities DSI from K-deltas dual force platforms (Kinvent Physio, Montpellier, France) [4]. The 30 s tethered swimming test was employed to ascertain the mean force at each 10 s interval and the fatigue index (Swimforce V1.0.0, Germany). AnCV was obtained from 10, 15, and 25 m front crawl and butterfly distances at maximal intensities [5]. Additionally, 50 m front crawl and butterfly bouts were conducted to assess swimming performance (v) and stroke rate, stroke length and stroke index. The association between the studied variables and front crawl and butterfly swimming performance are presented in Figure 1. A very large to nearly perfect positive correlation with AnCV, SI and 10-30 s mean force was observed in front crawl ($p<0.05$). Data suggest that coaches should focus on implementing strength and conditioning programs aiming at developing explosive power and anaerobic capacity to enhance agegroup sprint swimming performance. It seems to be important to balance anaerobic capacity, stroke efficiency and neuromuscular performance (especially the strength and power of the upper limbs) for optimal 50 m front crawl and butterfly swimming performance in a cohort of regional level early adolescent swimmers.



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11. Pilot study of the utility and agreement of heart rate measuring devices in swimming

Silva, V.[1], Pereira, A.[1], Morais, G.[1], Teixeira, J.E.[1,2,3], & Bartolomeu, R.F.[1,3,4,5*]

[1] Polytechnic of Guarda, Guarda, Portugal
[2] Polytechnic Institute of Cávado and Ave, Guimarães, Portugal
[3] Sport physical activity and health research & innovation center (SPRINT), Rio Maior, Portugal
[4] Instituto Politécnico de Bragança, Bragança Portugal
[5] Research Center for Active Living and Wellbeing (LIVEWELL), Bragança, Portugal

*Corresponding author: bartolomeu@ipg.pt

In the aquatic environment, controlling training or competition performance based on physiological parameters becomes almost impractical. Looking at heart rate (HR) for example, in land-based activities, in addition to chest straps, which are valid and reliable, several portable optical measurement devices have recently become available on the market and have demonstrated some robustness in measuring HR (Navalta et al. 2020). However, evaluations of measurement agreement between methods are commonly performed on land, leaving it unclear whether the same technology would work in aquatic environments. This is because, for example, the body or body segments displacement through the water during actual swimming can lead to the passage of water between the sensors and the skin, which can interrupt or disrupt the measurement. Recently, one of the sensors available on the market was equipped with a clip that allows it to be attached to the strap of swimming goggles. In this case it reads the HR data from the temple, covered by the swimming cap, which in theory can overcome the difficulties mentioned above. The objective of this study was to evaluate the usefulness of a device with an optical sensor as a HR meter during front-crawl swimming and, simultaneously, to test the measurement agreement with the chest strap. The sample consisted of 24 individuals (16 males and 8 females) (21.62±4.35 years old, 67.20±7.59kg and 172.80±6.15 cm). Participants were tied at the waist level to the starting block with a static rope. Each person performed a test that consisted of three sets of 30 s with progressive, self-selected rhythms, followed by a 1-min rest period. During the entire test, students wore a chest strap (H10, Polar, Filândia) placed at the level of the xiphoid process and an optical sensor (OH1+, Polar, Filândia) placed on the right temple, attached to the glasses strap, under the swimming cap. The relationship between the HR captured by the chest strap and by the optical sensor was moderate (R2=0.44). The interclass correlation was good (ICC=0.75, 95%CI: 0.66 and 0.81) and the Bland-Atlman plot revealed that more than 80% of cases were within the 95% CI limits. An individual analysis revealed a tendency for greater variance between methods in the first 30s of the test. There appears to be a “delay” for the optical sensor in capturing the subject’s actual HR. From then on, both the relationship and agreement between the methods increases. In other words, the results may be affected by this adaptive period. It is suggested that, in future tests, the optical sensor be connected earlier to allow for a correct measurement from the optical sensor. Measuring HR at the temple with the optical sensor can be an alternative to the traditional chest strap. As swimmers take their temples out of the water regularly (when breathing), the application made available by the sensor brand can be used to monitor athletes' HR in real time with relative safety.

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12. The effect of the type of breathing on open water swimming

Gonçalves, C.[1*], Louro, H.[3], Santos, M.[2], Stastny, J.[4], Torres, D.[2], & Conceição, A.[2,3]

[1] Faculty of Sports of Cáceres, University of Extremadura, Extremadura, Spain
[2] School of Sports of Rio Maior, Polytechnic Institute of Santarém (ESDRM-IPS), Santarém, Portugal
[3] Research Center in Sports, Health, and Human Development (CIDESD), Vila Real, Portugal
[4] Brno University of Technology, Centre of Sports Activities, Brno, Czech Republic

*Corresponding author: cgoncalvr@alumnos.unex.es

In swimming, athletes compete in various environments. Open water swimming, specifically, entails several differences compared to pool swimming and necessitates specific preparation and skills (1). In the field of biomechanics, the investigation of competitive swimming using electromyography (EMG) has predominantly focused on establishing relationships between neuromuscular activity and kinematics (2). The aim of this study was to examine the prevalence of different breathing techniques throughout the entire course, as well as to assess muscle activation in swimmers. The sample comprised nine male swimmers (mean age: 25.4 ± 11.9 years; body weight: 75.9 ± 9.0 kg; height: 180.7 ± 6.7 cm; wingspan: 185.6 ± 10.3 cm), with a minimum of five years of training experience at both national and international levels, with regular participation in the National Open Water Circuit. All swimmers participated in the National Open Water Championship and completed the event. Each swimmer was individually assessed in an open-water environment (lake), swimming 5x1000 meters at maximum intensity. Muscle activity was measured using surface electromyography, applied along the longitudinal midline of the target muscle following the SENIAM Project recommendations (2009), in seven muscles: Upper Trapezius (UT), Latissimus Dorsi (LD), Pectoralis Major (PM), Posterior Deltoid (PD), Anterior Deltoid (AD), Triceps Brachii (TB), and Biceps Brachii (BB). To verify the normality of the data, the Shapiro-Wilk test was conducted. As the data demonstrated normality with $p>0.05$, parametric repeated measures ANOVA were employed, interpreted using Greenhouse-Geisser corrections. Subsequently, the post-hoc test facilitated the comparison among different breathing conditions. The TB and PM muscles exhibited higher muscular activity during the underwater phase, whereas the LD muscle was the least recruited. In the recovery phase, the most recruited muscles were the UT, PD, and AD. Significant differences were observed in the TB ($F=1.84$, $p=0.07$, $\eta^2=0.18$) and PM ($F=4.15$, $p=0.00$, $\eta^2=0.34$) muscles during the course with alternate breathing. The AD muscle ($F=3.65$, $p=0.00$, $\eta^2=0.31$) demonstrated significant differences at distances of 1000m, 2000m, 3000m, and 5000m under directional breathing conditions in both phases. An average speed of 1.35 m/s was recorded, consistent with our results of 1.33 m/s, attributable to performance in open-water environments and the application of similar protocols (3). In the study of a 5000m swim in a 50m pool, the IB variable exhibited a tendency to decrease over the course (3.4 m²/s/cycle), closely aligning with our results (4.00 m²/s/cycle). Swimmers favoured alternate breathing techniques. Throughout the entire course, under both directional and alternate breathing conditions, the UT muscle demonstrated greater activation during the recovery phase. Conversely, the LD muscle exhibited the lowest muscle activation during the underwater phase under both breathing conditions.

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13. Neuromuscular fatigue in open water swimmers

Gonçalves, C.[1], Conceição, A.[2,3], Stastny, J.[4], Santos, M.[2], Torres, D.[2], Louro, H.[2,3]

[1] Faculty of Sports of Cáceres, University of Extremadura, Extremadura, Spain
[2] School of Sports of Rio Maior, Polytechnic Institute of Santarém (ESDRM-IPS), Santarém, Portugal
[3] Research Center in Sports, Health, and Human Development (CIDESD), Vila Real, Portugal
[4] Brno University of Technology, Centre of Sports Activities, Brno, Czech Republic

Corresponding author: N/A

Background: Open water swimming is a demanding sport that requires athletes to contend with variable environmental conditions such as water temperature, currents, and waves, which can significantly contribute to fatigue. Electromyography (EMG) is a valuable tool for assessing muscle fatigue and activity during swimming, providing insights into the physiological demands placed on swimmers (Puce et al., 2022). Purpose: The aim of this study is to verify the effect of the fatigue in open water swimmers. Methods: Nine male swimmers (25.4 ± 11.9 years; Average body weight of (75.9 kg ± 9.0), height of (180.7 cm ± 6.7), and wingspan of (185.6 cm ± 10.3). Each swimmer was performed in an open-water lake environment 5x1000 meters at maximum effort. Muscle activity was monitored using surface electromyography on seven muscles along the longitudinal midline, following the SENIAM Project's 2009 guidelines. Upper Trapezius (UP), Latissimus Dorsi (LD), Pectoral Major (PM), Posterior Deltoid (PD), Anterior Deltoid (AD), Triceps Brachii (TB), Biceps Brachii (BB). Results: All the muscles had a significant decrease on muscular activity except for the PD that had an increase at the end of the test. The muscle PD had a decreased of 60%RMS on the muscular activity since the start till the end, but the PM had an increase of 39%RMS. The only muscle with significant differences was the PM p-value (0,042). UT500 and PD500 have a significant positive correlation ($r = 0.716$, $p = 0.030$), PD500 and BB500 have a strong significant positive correlation ($r = 0.935$, $p = 0.000$), indicating a very strong relationship between these two variables. UT5000 and AD5000 show a significant positive correlation ($r = 0.732$, $p = 0.025$). Conclusion: We can conclude that with the appearance of the fatigue, the Pectoral Major and Latissimus Dorsi start to compensate the lower muscular activity on the other muscles.

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14. Analysis of upper limb thrust in assisted front-crawl swimming using statistical parametric mapping

Moriyama, S.-I.[1,2*], Watanabe, Y.[3], Toyoday, Y.[4,5], Morais, J.E.[6,7], Neiva, H.P.[1,8], & Marinho, D.A.[1,8]

[1] Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, Covilhã, Portugal
[2] Department of Health and Sports Sciences, Tokyo Gakugei University, Koganei, Japan
[3] Department of Sports Sociology and Health Sciences, Kyoto Sangyo University, Kyoto, Japan
[4] General Education Organization, Momoyama Gakuin University, Izumi, Japan
[5] The United Graduate School of Education, Tokyo Gakugei University, Koganei, Japan
[6] Instituto Politécnico de Bragança, Bragança, Portugal
[7] Research Centre for Active Living and Wellbeing (LiveWell), Instituto Politécnico de Bragança, Bragança, Portugal
[8] Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal

*Corresponding author: moriyama@u-gakugei.ac.jp

Tethered swimming is a traditional training method used in competitive swimming, in which swimming speed is artificially controlled. It is classified into two types: assisted (the swimmer is pulled in the direction of propulsion) and resisted (the swimmer is pulled in the opposite direction of propulsion). Despite its popularity, there are few studies of assisted swimming compared to the resisted type (Girold et al., 2006). Although assisted swimming can increase speed, it has been reported that it can alter the swimmer's stroke mechanics and increase the stroke frequency (Williams et al., 2006). However, no study has quantified upper limb thrust during assisted swimming. The aim of this study is to clarify the impact of different towing loads on thrust during assisted towing with front-crawl swimming. Eleven male competitive swimmers from a university (height, 1.71 ± 5.7 m; weight, 64.3 ± 6.0 kg; 487 World Aquatics Points) performed assisted swimming with front crawl under five different loads (0, 5, 9, 14, and 18 kg) using a specific apparatus. There was a 5-min rest period between trials and the towing load was applied randomly. Thrust was measured using a pressure sensor system (Morais et al., 2020), and the data for three stroke cycles after the middle of the pool were analysed. Time-series thrust data were analysed using statistical parametric mapping, with the significance level set at 5%. Swimming speed significantly increased for all towing loads except the 14 to 18 kg conditions. Typically, assisted swimming with a load greater than the swimmer's own propulsive force results in higher speed compared to swimming without towing. Considering that the resistance to propulsion is proportional to the square or cube of speed (Narita et al., 2017), it is likely that in the present participants, the water drag generated during strong assisted towing at loads greater than 14 kg hindered forward propulsion. However, there was no significant difference in thrust among the towing loads except for a single stroke of the non-dominant hand at 14 kg. Concerns about a decrease in propulsion in semi-tethered swimming (Moriyama et al., 2022) do not appear to apply to assisted swimming at maximum effort. During maximum-effort assisted swimming, thrust is not affected by variation in the towing load.

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15. The effect of Dryland warm-up in water polo performance

Dias, J.N.A.[1,2*], Neiva, H.P.[1,2], & Marinho, D.A.[1,2]

[1] Research Centre in Sports Sciences, Health Sciences and Human Development, CIDESD, Covilhã, Portugal
[2] Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal

*Corresponding author: joao.nuno.alves.dias@ubi.pt

Warm-up routines have been studied in the last years, highlighting their crucial role in enhancing athletic performance across various sports (Gil et al.). Effective warm-ups not only optimise performance but also sustain these benefits throughout the competition (Silva et al.; Gil et al.). While coaches and players widely recognise the importance of pre-competition warm-ups in achieving optimal performance, scientific literature specifically addressing warm-up strategies in team sports, particularly water polo, remains limited. This study investigates the impact of Dryland warm-up (DWUP) versus no warm-up (NWUP) on water polo performance, aiming to address this gap in the literature and inform evidence-based coaching practices. Ten male water polo players at the national level (22.4 ± 3.53 years) randomly performed the match fitness test (WIST) (Mujika et al.). on two different days (48 hours between), after the usual DWUP or after NWUP. Blood lactate ([La-]) and heart rate (HR) were measured at baseline, before and after the performance test (WIST). The main results showed that the distance performed by athletes with the DWUP was not different from NWUP (226.5 ± 129.51 vs. 229.5 ± 74.18 m, p = 0.911, d = 0.04). Moreover, higher [La-] values were found after WIST without warm-up (15.26 ± 3.05 vs 12.62 ± 4.41 mmol/L, p = 0.12, d = 1). HR showed higher values before WIST assessment after DWUP (103.6 ± 15.49 vs 85.7 ± 18.49 bpm, p = 0.03, d = 1.26). This study demonstrated that the results of the NWUP condition are based on a superior response in the use of energetic pathways in water polo players, resulting in a greater reliance on anaerobic metabolism. This finding aligns with previous research in other sports, indicating a consistent effect of warm-up contribution on energy system pathways. However, the increased anaerobic contribution in NWUP may lead to performance limitations. Based on the results presented, the DWUP condition seems to enhance performance. Therefore, it is recommended to perform the DWUP condition, as it effectively prepares the body for the demands of water polo, ensuring more efficient energy use during the game.

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16. The effect of in-water warm-up in female water-polo performance

Dias, J.N.A.[1,2*], Neiva, H.P.[1,2], Neves, P.P.[1,2], & Marinho, D.A.[1,2]

[1] Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal
[2] Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, Covilhã, Portugal

*Corresponding author: joao.nuno.alves.dias@ubi.pt

Introduction: While warm-up (WU) routines are recognized for their performance-enhancing benefits in various sports (Gil et al., 2019), research specifically examining the impact of in-water warm-up (WINW) on female water polo performance remains limited. Given the unique physiological demands of water polo and the reliance on in-water activity, this study aimed to compare the effects of a standard WINW versus no warm-up (NWUP) on key performance indicators. Methods: Eight national-level female water polo athletes (age 21 ± 2) performed the water polo fitness test (WIST) (Mujika et al., 2006) on two occasions, with a 48-hour interval. They were randomized to control order effects, performing WIST after WINW and NWUP. The WINW included a 400-meter swim at 60-80% intensity, sprints and drills at 75-95% effort, and technical drills. Blood lactate [La-] and heart rate (HR) were measured at baseline, pre- and post-performance. Paired t-tests compared conditions using SPSS and G*Power, with significance at $p \leq .05$. Results: The players performed greater distance with the WINW than without warming-up (236.25 ± 113.32 vs. 196.88 ± 87.99m, t = 2,42, p = 0.046, d = 0.86). Moreover, higher [La-] values were found after WIST without warm-up (12.81 ± 3.61 vs 11.2 ± 4.19 mmol/L, p = 0.135, d = 0.6). HR showed higher values before WIST assessment after NWUP (96 ± 6.3 vs 87.63 ± 6.89 bpm, p = 0.007, d = 1.34). Conclusion: The findings suggest that in-water warm-up enhances distance performance during the WIST. Conversely, skipping warm-up appears to increase reliance on anaerobic pathways, evidenced by elevated blood lactate and HR levels, aligning with prior research (Gil et al., 2019). Coaches should consider implementing standardized warm-up protocols to maximize performance. While promising, the small sample size warrants caution; further studies with larger cohorts are needed to confirm these results.

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17. Comparison of the effects of water aerobics in different populations

Faíl, L.B.[1,2], Marinho, D.A.[1,2], Neves, P. P.[1,2], & Neiva, H.P.[1,2]

[1] Research Centre in Sports Sciences, Health Sciences and Human Development, CIDESD, Covilhã, Portugal
[2] Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal

*Corresponding author: luisfail_93@hotmail.com

Several studies have explored the acute and chronic effects of water aerobics on health and physical fitness (Andrade et al., 2020; Moreira et al., 2017). However, research comparing its effects on individuals of different ages remains limited. Thus, this research compared the effect of water aerobics on health-related variables in adults vs. older adults. For this, twenty individuals were assigned to two different groups. Each group participated in 45 minutes of water aerobics twice a week for 24 weeks. One group consisted of individuals aged between 18 and 64 years (Adults group; n = 10; 50.20 ± 2.70 years), while the other group included individuals aged 65 years or older (Older Adults group; n = 10; 73.40 ± 6.48 years). Participants underwent evaluation before and after the program. The assessments included muscle strength (countermovement jump [CMJ], medicine ball throw, chair stand test [CST], arm curl), anthropometric (body mass, body mass index, fat mass, fat-free mass), lipid profile (triglycerides, total cholesterol), and blood pressure (systolic and diastolic blood pressure). The Student's paired t-test was used to conduct a within-group analysis on each variable, and the effect size was calculated to estimate within-subject comparisons, using Cohen's d (ES). CMJ ($p = 0.04$; ES = 0.70) and diastolic blood pressure ($p = 0.03$; ES = -0.74) improved in Older Adults, while CST ($p = 0.04$; ES = 0.68) increased in Adults. Adults ($p = 0.02$; ES = 0.81) and Older Adults ($p = 0.01$; ES = 0.96) also demonstrated improvements in arm curl. Lipid profile and body composition variables showed no changes in either group. The study's results indicated that participating in water aerobics for 24 weeks improves diastolic blood pressure and explosive strength in the lower limbs of older adults and enhances muscular endurance in the lower limbs for adults. Additionally, adults and older adults can increase their upper limb muscular endurance through a water aerobics program. Overall, water aerobics is an effective way to increase muscle strength in adults and older adults.

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18. Effect of Three Rewarming-up Protocols on 100m Freestyle Turning Times in Competitive Swimmers

Paiva, D.[1,2*], Marinho, D.A.[1,2], Rama, L.[3], Neiva, H.P.[1,2], Dias, J.[1,2], Pinto, M.[1,2], Sampaio, T.[1,2,4], & Oliveira, J.[1,2,4]

[1] Research Centre in Sports Sciences, Health Sciences and Human Development, CIDESD, Portugal
[2] Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal
[3] Faculty of Sports Sciences and Physical Education, University of Coimbra, Coimbra,
[4] Portugal Research centre for Active Living and Wellbeing, Instituto Politécnico de Bragança, Bragança, Portugal

*Corresponding author: daniel.paiva@ubi.pt

Sports warming up is a well-recognised and researched practice that can benefit athletes' performance and prevent injuries. Many coaches point out the transition phase between warm-up and competition as one of the moments that pose obstacles to the performance of athletes, and a rewarm-up may be one of the strategies to mitigate the loss of the benefits achieved during the warm-up. The present study investigated the effects of three rewarming-up protocols (Control, Water and Dryland) on the swimming turns during a 100m Freestyle time trial. The study included 20 male volunteer swimmers, aged between 16 and 27 years (Mean = 18.30 ± 2.77 yrs). The sessions were conducted with a 24-hour interval between them. The athletes started the sessions with a Dryland warm-up (10 min) and a 1200m warm-up in the pool (25 min). During the Transition Phase, athletes had 15 minutes to change into their swimming suits and began the rewarm-up that was randomly assigned to them. Then, they wore their uniforms (t-shirt and shorts) and went to the call room (20 min). The athletes did not rewarm-up in the Control session, remaining seated and equipped for 5 minutes. In the Water session, athletes performed a warm-up in the pool (50m Build-up, 20m Build-up, 20m Race Pace, 10m A1, 25m A1, 15m Build-up, 10m Race Pace, 50m A1) @1.30. In the Dry session, athletes performed 3 sets of: 3x medicine ball (4kg) throw downs + 3x tuck jumps @1 min. Turn time was calculated considering the 5 meters approaching the wall and the following 10 meters. Differences between variables were determined by repeated measures ANOVA test ($p \leq 0.05$), and differences between groups were calculated using Post Hoc, applying the Bonferroni correction. We observed a tendency for a progressive increase in the average values of turning times in the three protocols over the distance. In the Water protocol, times present a minor variation and lower values, while higher values are presented in the Control protocol. No differences were shown between conditions in turning times. However, as the distance increases, the comparison effect also appears to increase, although in the first and second turning times (TT1, TT2) the effect was small ($\eta^2=0.026$, $\eta^2=0.027$) and in the third turning time (TT3) the effect was medium ($\eta^2=0.055$). The effect would be demonstrated by comparing Control vs. Water (TT1 p=1, TT2 p=0.700 and TT3 p=0.602). The results show that the turning times increase as the distance increases, probably due to fatigue. Performing a rewarm-up seems to contribute to better performances in turns, with the water rewarm-up seeming to bring more advantages, since times were lower, probably due to better technical balance during the race, which may have resulted from the specific technical work carried out during the protocol.

Table1. Mean values and respective standard deviations of the recorded turning times, as well as ANOVA and post-hoc test results.

95% Interval de Confidence			ANOVA			Post-hoc	
		(Mean ± DP)	F	p	η^2	Comparation	p
TT1	Control	8.18 ± 0.41	0,510	0,604	0,026	Control vs. Water	1,000
	Water	8.15 ± 0.38				Control vs. Dryland	1,000
	Dryland	8.15 ± 0.43				Dryland vs. Water	1,000
TT2	Control	8.34 ± 0.48	0,521	0,598	0,027	Control vs. Water	0,700
	Water	8.29 ± 0.48				Control vs. Dryland	1,000
	Dryland	8.31 ± 0.54				Dryland vs. Water	1,000
TT3	Control	8.84 ± 0.52	1,114	0,339	0,055	Control vs. Water	0,602
	Water	8.76 ± 0.47				Control vs. Dryland	0,913
	Dryland	8.78 ± 0.50				Dryland vs. Water	1,000

Note: TT, Turning Time

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19. Relationship between Swimming Speed and Propulsive Force in Butterfly Swim Stroke

Pinto, M.P.[1,2*], Neiva, H.P.[1,2], Barbosa, T.M.[3,4], Marinho, D.A.[1,2], & Morais, J.E.[3,4]

[1] Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal
[2] Research Centre in Sports Sciences, Health Sciences and Human Development (CIDESD), Covilhã, Portugal
[3] Department of Sport Sciences, Polytechnic Institute of Bragança, Bragança, Portugal
[4] Research Centre for Active Living and Wellbeing (LiveWell), Bragança, Portugal

*Corresponding author: mafalda.maria.pinto@ubi.pt

Swimming performance is influenced by various biomechanical factors, with propulsive force playing a crucial role in determining swim velocity. Studies have demonstrated that higher propulsive forces are associated with increased swimming speeds (Lopes et al., 2023; Morais et al., 2021). Although some research has addressed this relationship in front crawl (Marinho et al., 2022), there is still a need for further investigation across different swimming strokes, including butterfly stroke. Understanding the interaction between propulsive force and swimming speed in butterfly swimming stroke is essential for optimising performance and developing targeted training interventions. This study aimed to understand the relationship between swimming speed and propulsive force in the butterfly swim stroke. Eight competitive male swimmers (18.58 ± 2.69 years, 77.14 ± 9.80 Kg of body mass, 184.38 ± 9.72 cm of height, 188.25 ± 7.78 cm of arm span, 612.14 ± 60.22 of WAPS) who regularly participate in national and international level competitions were analysed. Swimming speed was measured with a speedometer (SpeedRT, ApLab, Rome, Italy). Propulsive force was measured with SmartPaddles (Trainsense, Tampere, Finland). A simple linear regression analysis was performed to determine the relationship between swimming speed and propulsive force. The regression analysis between swimming speed (1.58 ± 0.10) and propulsive force (42.81 ± 5.30) revealed a significant positive correlation (R^2 = 0.63, p = 0.018). Propulsive force explained 63% of the swimming speed variance, indicating that it is a strong predictor of the latter. This highlights the crucial role of propulsive force application in enhancing performance.

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20. Comparison of Aquatic Literacy Levels in European children aged 6 to 12 years for safe and sustainable aquatic physical activity

Mekkaoui L.[1], Costa A.M.[2], De Martelaer K.[3], Legrand A.[1], Staub I.[4], Potdevin, F.[1], & ALFAC Consortium[‡]

[1] Univ. Lille, Univ. Artois, Univ. Littoral Côte d'Opale, ULR 7369 - URePSSS - Unité de Recherche Pluridisciplinaire Sport Santé Société, 59000, Lille, France, Lille, France
[2] Department of Sport Sciences, University of Beira Interior, Covilhã, Portugal; Research Center in Sport Sciences, Health Sciences and Human Development, CIDESD, Vila Real, Portugal, Vila Real, Portugal
[3] Movement and Nutrition for Health and Performance (MOVE) Research Group, Department of Movement and Sport Sciences, Faculty of Physical Education and Physiotherapy, Vrije Universiteit Brussel, Brussels, Belgium, Brussels, Belgium
[4] Institute of Professional Sport Education and Sport Qualifications, German Sport University Cologne, Cologne, Germany, Cologne, Germany
[‡] Costa, M. J., D'Hondt, E., Fernandes, R.J., Garrido, N.D., Kwasna, A., Ljødal, I., Olstad, B.H., Rejman, M., Rudnik, D., Santos, C.C., Simonsen, E., Soares, S., Van Droogenbroeck, L., Vilas-Boas, J.P., Vogt, T.

*Corresponding author: N/A

Grounded in the Water Competencies[1] model and the Physical Literacy concept[2], Aquatic Literacy (AL) encompasses both drowning prevention and the promotion of lifelong engagement in aquatic activities by fostering motor, psychosocial, and cognitive competencies in individuals. Recently, the Aquatic Literacy For All Children (ALFAC) test battery was developed to assess children's AL levels across Europe. This study presents the first comparison of AL levels among children aged 6-to-12-year-olds across six European countries (Belgium, France, Germany, Norway, Poland, Portugal), providing valuable insights to inform and enhance aquatic education programs. A total of 1,441 pupils (50% girls) aged 6-to-12-year-olds from six European countries participated in the ALFAC test battery. The assessment included a child questionnaire assessing psycho-social and cognitive competencies (motivation, enjoyment, confidence, risk perception, engagement in water sport, and self-perception) and aquatic tests designed to assess motor protective competencies (9 isolated tasks and a combined task test). Generalised linear models were used to analyse the sex, age, and country effects ($p<0.05$) with post-hoc analyses and effect sizes calculations (Cohen's *d*). The questionnaire results indicated no significant effects of age, sex, or country. Overall, children exhibit a strong motivation and enjoyment to learn swimming. Age effect was shown in the isolated aquatic tasks ($p<0.001$) with younger children (aged 6-7) demonstrating lower proficiency in treading water, submersion, and propulsion tasks. Country effect was shown ($p<2.14^{-7}$) on isolated task with low level in propulsion task in France and treading water in Poland, whereas high performance in belly propulsion in Germany. Despite 6-to-7-year-olds' high scores on motivation, enjoyment and confidence, their low level on isolated tasks may increase their drowning risk in swimming pools and also in open water. Empirical data on the AL level of children aged 6-to-12-year-olds in Europe, and analysis of the age, sex and country effects provide an understanding on the levels of motor, psychosocial and cognitive competencies necessary to engage safely and sustainably in the aquatic environment. Cross-country differences in motor skills suggest variations in curricula or teaching methods. Sharing best practices across nations could enhance water safety education and better protect children across Europe.

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21. Evaluation of Protective Drowning Prevention Skills in a Decision-Making Scenario: Introduction to the ALFAC 'Parcours'

Potdevin, F.[1], Costa A.M.[2], De Martelaer K.[3], Legrand A.[1], Staub I.[4], Mekkaoui L.[1], & ALFAC Consortium[‡]

[1] Univ. Lille, Univ. Artois, Univ. Littoral Côte d'Opale, ULR 7369 - URePSSS - Unité de Recherche Pluridisciplinaire Sport Santé Société, 59000, Lille, France, Lille, France
[2] Department of Sport Sciences, University of Beira Interior, Covilhã, Portugal; Research Center in Sport Sciences, Health Sciences and Human Development, CIDESD, Vila Real, Portugal, Vila Real, Portugal
[3] Movement and Nutrition for Health and Performance (MOVE) Research Group, Department of Movement and Sport Sciences, Faculty of Physical Education and Physiotherapy, Vrije Universiteit Brussel, Brussels, Belgium, Brussels, Belgium
[4] Institute of Professional Sport Education and Sport Qualifications, German Sport University Cologne, Cologne, Germany, Cologne, Germany
[‡] Costa, M. J., D'Hondt, E., Fernandes, R.J., Garrido, N.D., Kwasna, A., Ljødal, I., Olstad, B.H., Rejman, M., Rudnik, D., Santos, C.C., Simonsen, E., Soares, S., Van Droogenbroeck, L., Vilas-Boas, J.P., Vogt, T.

*Corresponding author: N/A

Background: Assessing children's protective aquatic skills is a key objective of the Aquatic Literacy For All Children (ALFAC) project. The model of Stallman et al. (2017)1 highlights fundamental aquatic skills (FAS) essential for protecting children from drowning. Additionally, information processing while moving in the aquatic environment is critical for water safety. Therefore, evaluating the ability to combine FAS with real-time information processing (i.e., visual and auditory information-taking as well as decision-making) is essential to determine children's ability to cope with various drowning scenarios2. This study aims to identify differences between boys and girls aged 6-7, 8-9 and 10-12 years across six European countries (i.e., Belgium, France, Germany, Norway, Poland and Portugal) in their ability to perform a combined aquatic skills task test while making real-time decisions. Methods: A total of 617 school-aged children (46% girls) from six European countries participated in an aquatic combination task test: the 'Parcours'. The test combines six FAS (i.e., entry into the water, treading water, swimming on the belly, back, underwater, and exiting the water) with visual and auditory information processing and in-action decision-making. Performance in each task was assessed on a binary scale (i.e., succeed vs. failure) using predefined criteria validated by internal and external experts (ALFAC Manual). A generalised linear model was used to analyse the effects of sex, age and country, along with their interactions on the children's 'Parcours' performance ($p<0.05$). Results: The overall success rate across the various aquatic skills tasks within the 'Parcours' was high (90%). The most challenging tasks required a combination of motor, psychological and cognitive competencies, particularly treading water while processing visual information and making real-time decisions. While no sex effect was observed, children's performance differed significantly by age ($p<0.01$) and country ($p<0.001$) in these more complex tasks. Conclusion: The ALFAC 'Parcours' test appears to be a highly informative tool for assessing children's ability to integrate FAS with real-time information processing and decision-making in an aquatic environment. Implementing a common assessment test across multiple countries could help to identify strengths and weaknesses in global water safety education, ultimately informing and improving swimming instruction worldwide.

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22. Perceived vs. Actual Aquatic Competence in Primary School Children: Age and Sex Effects

Ribeiro, R.[1,2], Garrido, N.D.[1,2,3], Costa, M.J.[2,4], Santos, C.C.[1,2], Martins, J.[2,3,5], & Costa, A.M.[2,3,5*]

[1] Department of Sport Sciences, Exercise and Health, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal
[2] Portuguese Swimming Coaches Association (APTN), Rio Maior, Portugal
[3] Research Centre in Sport Sciences, Health Sciences and Human Development (CIDESD), Covilhã, Portugal
[4] Centre for Research, Education, Innovation and Intervention in Sport, CIFI2D, Faculty of Sport, University of Porto, Porto, Portugal
[5] Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal

*Corresponding author: mcosta.aldo@gmail.com

Drowning incidents can result in severe consequences, including death or permanent health impairments, and can be reduced through the development of aquatic competence (Garrido, Costa, & Stallman, 2016). A core objective of the European project "Aquatic Literacy For All Children" (ALFAC) is to characterise the protective skills essential for survival in aquatic environments under the concept of aquatic literacy. This study analysed the relationship between perceived (PAC) and actual aquatic competence (AAC) in primary school children, examining the effects of sex and age on aquatic literacy. A total of 80 children aged 6 to 11 years (n=40 boys; n=40 girls; 8,89±1,04 yrs old), enrolled in four elementary schools in Portugal were assessed on their AAC using the ALFAC test battery tools (Van Droogenbroeck, Mekkaoui, & De Martelaer, 2024): a parent questionnaire, a child questionnaire evaluating psychosocial and cognitive competencies (including perceived aquatic competence), and real-life aquatic tests measuring nine isolated tasks. Pearson correlation coefficients, independent t-tests ($\alpha = 0.05$), and generalised linear models with an ordinal distribution ($p < 0.05$) were used to analyse sex and age effects, with effect sizes interpreted using Cohen's d. Only 8.75% of parents or guardians considered their children safe or very safe in deep water without supervision or flotation aids, despite children's confidence. Differences were found between PAC and AAC in most isolated tasks, with children generally overestimating their abilities: entry ($p<0.001$, $d=0.732$), exit ($p<0.001$, $d=0.724$), horizontal body rotation ($p<0.001$, $d=-0.453$), treading water ($p<0.001$, $d=0.490$), dorsal propulsion ($p<0.001$, $d=-0.913$), ventral propulsion ($p<0.001$, $d=1.337$), submersion ($p<0.001$, $d=0.814$), and floating ($p<0.001$, $d=0.882$). Correlations between PAC and AAC were modest across all skills. Results suggest that older children demonstrate higher aquatic competence in several aquatic tasks (entry, exit, vertical, horizontal and tilting body rotation, floating, dorsal and ventral propulsion) ($p<0.001$). A sex effect was found in four tasks (entry, exit, ventral propulsion and submersion), with boys outperforming girls ($p<0.05$). Findings highlight the need for structured aquatic education programs tailored to children's developmental stages to bridge the gap between perceived and actual competence and improve water safety.

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23. Acute physiological response and perceived effort of older women while exercising with different limb strategies during water fitness exercises

Carrijo, V.H.[1], Cruz, L.[2], Souza, L.[1], Machado, M.L.[1], Santos, C.C.[3], & Costa, M.J.[1*]

[1] Center for Research, Education, Innovation and Intervention in Sport, CIFI2D, Faculty of Sport, University of Porto, Portugal
[2] Department of Sport Sciences, Polytechnic of Guarda, Guarda, Portugal
[3] Higher Education School, Polytechnic of Coimbra, Coimbra, Portugal

*Corresponding author: mjcosta@fade.up.pt

Appropriate physiological adaptations during water fitness exercises can be obtained depending on the type of exercise performed (Barbosa et al., 2009). The use of different limb strategies can increase complexity and, as a consequence, the cardiovascular demand (Costa et al., 2019). However, it remains unclear if a distinct combination of limbs may trigger different physiological responses. This study aimed to compare the acute physiological response and perceived effort of older women while exercising with different limb strategies during water fitness exercises. Eight women (61.5 ± 5.98 years, 1.57 ± 0.09 m of height, 65.56 ± 10.16 kg of body mass and 26.63 ± 3.88 kg/m^2 of body mass index) were randomly assigned to perform horizontal arm abduction (Ab), frontal kick (Fk), and aquatic skiing (Ski). The effort was performed over five minutes at a cadence of 132 beats per minute controlled by a metronome (Korg, MA-30, Tokyo, Japan). The physiological response was characterised by the heart rate (HR), systolic (SBP) and diastolic (DBP) blood pressure, double product (DPr) and blood lactate [La-]. The percentage of the predicted maximal theoretical HR (%HRmax) was also determined (HRmax = 208 – 0.7 * age). The Borg's scale assessed perceived effort (RPE). The within-exercise comparison was tested using repeated measures ANOVA, followed by a Bonferroni post-hoc test, and adding the partial eta squared (η_p^2) as an effect size. The women reached 65.69 ± 11.00% in Ab, 64.98 ± 9.19% in the Fk and 64.05 ± 6.72% in Ski of their %HRmax. While no differences were found in the physiological response between exercises, the women perceived a higher effort when performing the Fk. Although some water fitness exercises may not trigger different acute physiological responses, the participants in a water fitness session may perceive intensity differently as it happens when devices are used (Costa et al., 2019). Actions involving only the lower limbs (i.e. kicks) promoted a higher perceived effort, which can be explained by the need to overcome the impulse during the downward phase of the movement, since this does not happen in the remaining exercises. So, water fitness professionals can be advised that the number of limbs in action may not solely determine the acute physiological response. The exercise mechanics should also be considered, even if having a lower number of limbs in action, as it may be perceived as more challenging by people of this age cohort.

Table 1. Comparison of physiological response and perceived effort between the different water-based exercises.

Variable, unit	Exercise			ANOVA		
	Ab	Fk	Ski	F	p	η_p^2
HR, bpm	102.38±6.84	103.50±21.69	105.00±16.67	0.05	0.95	0.00
SBP, mmHg	111.88±11.34	122.88±8.31	119.13±13.97	1.83	0.20	0.21
DBP, mmHg	72.63±14.96	74.00±10.85	71.88±15.50	0.15	0.85	0.02
DPr	11462±1471	12744±2922	12545±2645	0.56	0.59	0.07
[La-], mmol/L	3.63±1.82	3.23±1.42	3.00±1.64	1.35	0.29	0.16
RPE	8.75±1.28*	10.63±1.85	9.38±2.39	4.49	0.03	0.39

*, different from Fk; Ab, horizontal arms abduction; Fk, frontal kick; Ski, aquatic skiing; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; DPr, double product; [La-], blood lactate concentrations; RPE, rating of perceived effort; bpm, beats per minute.

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24. Understanding the women's force transfer from land to water during the alternate elbow extension-flexion

Carrijo, V.H.[1], Souza, L.[1], Machado, M.L.[1], Costa, M.J.[1], & Santos, C.C.[2,3*]

[1] Centre for Research, Education, Innovation and Intervention in Sport, CIFI2D, and Porto Biomechanics Laboratory, LABIOMEP, Faculty of Sport, University of Porto, Portugal
[2] Higher Education School, Polytechnic of Coimbra, Coimbra, Portugal
[3] Department of Sport Sciences, Higher Institute of Educational Sciences of the Douro, ISCE-Douro, Penafiel, Portugal

*Corresponding author: catarinamsantos@esec.pt

Previous studies in water fitness focused on applied in-water forces during basic exercises (Santos, Barbosa, Bartolomeu et al., 2020). Although an alternate elbow extension-flexion (EE-F) exercise can be considered a more proper strategy (Santos, Barbosa & Costa, 2020) than a simultaneous action, little is known about the degree of strength transfer from land to water while performing such water fitness movement. This study aimed to analyse the women's relative force transfer from land to water during the EE-F by the elbow in a water fitness session. Ten middle-aged women (age: 58.63±5.03 years old; body mass: 68.77±10.60 kg; height: 161.55±6.68 cm) performed EE-F while undergoing an incremental protocol with four music cadences (105, 120, 135 and 150 bpm). The music cadence was controlled by a metronome (Korg, MA-30, Tokyo, Japan) plugged into a sound system. A 3-minute warm-up, preceded by stationary running at low amplitude and intensity, was considered before the main protocol. In-water forces of dominant (F, in N) were assessed using a differential pressure system composed of one sensor (Aquanex 4.1, STR, USA). Only the flexion peak values were considered for further analysis. Isometric strength (IS, in N) at 90° elbow flexion on land was assessed using the MicroFET®2 hand-held dynamometer, considering the dominant limb. The relative force transfer was calculated as RFT = [(100 * FD) / (ISD)]. Repeated-measures ANOVA followed by the Bonferroni post-hoc test was used to verify differences in F and RFT throughout the incremental protocol. The partial eta squared (η_p^2) was selected as an effect size measure. Women were able to reach 75.9±11.4 N during IS on land. Table 1 shows the comparison of F and RFT throughout the incremental protocol of EE-F. Differences were found between the four music cadences for F ($F(1.7, 15.1) = 58.4$, $p<0.001$, $\eta_p^2 = 0.9$) and RFT ($F(1.6, 14.4) = 57.7$, $p<0.001$, $\eta_p^2 = 0.9$). The understanding of strength transfer into water fitness exercises is a key aspect for fitness professionals to prescribe adequate programs for strength development. Middle-aged women showed a tendency to increase RFT when increasing the music cadence, showing values from ~18 N (105 bpm) to ~39 N (150 bpm). A similar tendency was found by Santos and Costa (2021) while assessing the upper-limb horizontal adduction. Despite this, the authors found a higher RFT (~64%) at the cadence of 150, which can be explained by the mechanics of the movement (e.g., lever length). So, water fitness professionals should be aware that this type of exercise (i.e., EE-F) may not be suitable to achieve the recommended guidelines (~60%–80% of the one repetition maximum) for improving muscular strength during a water fitness session.

Table 1. Descriptive analysis and comparison of F and RFT during the incremental protocol of EE-F.

Variables, units	Music cadences (bpm)			
	105	120	135	150
F, N	13.7±4.3*	17.6±4.4*	22.5±6.1*	29.5±7.7*
RFT, %	17.9±3.8*	23.1±4.3*	29.6±6.2*	39.1±9.0*

*, different from the all-remaining cadences; F, in-water force; RFT, relative force transfer; bpm, beats per minute

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25. Swim Spektro Dynamometry: Applications

Costa, M.J.[1,2]

[1] Centre for Sports Research, Education, Innovation and Intervention in Sport, CIFI2D, Faculty of Sport, University of Porto, Portugal
[2] Porto Biomechanics Laboratory, LABIOMEP, Faculty of Sport, University of Porto, Portugal

*Corresponding author: N/A

The assessment of propulsive forces in swimming remains a persistent challenge due to the complexity of the aquatic environment and the difficulty of obtaining reliable measurements under ecological conditions [1]. The Swim Spektro is a dynamometry system designed to quantify the force applied in the water through three distinct modes: tethered swimming, semi-tethered swimming and towing. The system integrates a high-precision load cell that allows continuous real-time force data collection, enabling both quantitative and qualitative analyses of swimming cycle mechanics and the consistency of force production throughout any aquatic locomotion (Figure 1). The applications of the Swim Spektro are diverse. It provides objective information on individual in-water strength, assisting coaches in defining specific workloads and monitoring performance progression across the season. In research, the system constitutes a robust tool to explore the relationships between limb's strength and swimming, as well as to analyze inter- and intra-individual variability patterns [2]. The towing mode further expands the applicability of the device by allowing simulations of drag conditions and the study of hydrodynamic influences considering different body positions or testing different drag devices [3]. However, the Swim Spektro application is not limited to sports, and could be used in the clinical and/or rehabilitation contexts when water is seen as an appropriate environment for injury management and recovery.

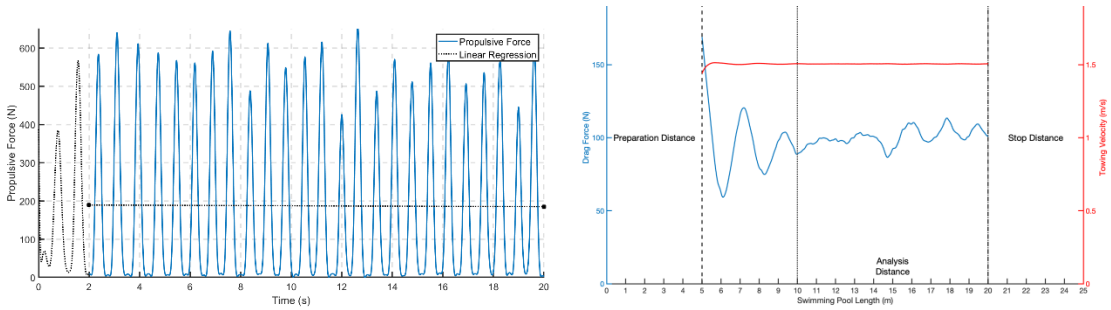


Figure 1. Swim Spektro force-time curve profiles in tethered (left side) and towing (right side) modes.

Thus, the Swim Spektro represents an innovative and versatile solution for applied assessment in the aquatic environment, offering objective data to support training decisions and contributing to the advancement of scientific knowledge on human aquatic locomotion.

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26. Understanding front crawl efficiency: kinematic adaptations across swimming paces

Borda, I.[1], Fernandes, A.[1], Costa, M.J.[1], & Fernandes, R.J.[1]

[1] Centre of Research, Education, Innovation and Intervention in Sport and Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, Portugal

*Corresponding author: N/A

Optimizing swimmers technique across different paces is a key challenge for coaches (1). Since swimming intensity significantly affects kinematics (2,3,4), this study aimed to explore the relationship between front crawl kinematics and efficiency at varying paces. Sixteen swimmers (8 females and 8 males: 26.1±5.8 and 23.6±4.4 years old, 60.3±6.0 and 73.8±6.2 kg of body mass, 170.1±4.0 and 180.6±4.2 cm of height and 453±36 and 553.3±56 World Aquatics points in short course 50 m front crawl event, respectively) performed 20 randomized 25 m front crawl trials at 83, 88, 93 and 100% of maximal intensity, as well as maximal intensity towing a hydrodynamic body. Velocities were controlled using flashing lights and performances were recorded using an underwater camera. Mean, relative maximum and minimum velocities, intracycle velocity variation, stroke index, stroke rate and length, hydrodynamic drag and the power to overcome drag were calculated. A repeated measures ANOVA was used to compare variables between four paces, followed by a post hoc Bonferroni test. Among female swimmers, mean velocity, stroke rate, and stroke length increased with intensity, while relative minimum and maximum velocity, swimming index, and intracycle variation remained unchanged. Hydrodynamic drag and power to overcome drag increased with intensity. Among males, mean velocity, stroke rate, and stroke length varied significantly across paces, generally increasing with intensity, while hydrodynamic drag and power to overcome drag followed the same trend. Relative minimum and maximum velocity remained stable (Figure 1). Swimming intensity significantly impacts front crawl kinematics and efficiency, requiring technical adjustments across paces. Stroke rate and length are key to speed regulation, while higher intensities increase hydrodynamic drag and the power needed to overcome it. These findings support targeted training strategies to optimize efficiency and manage energy use.

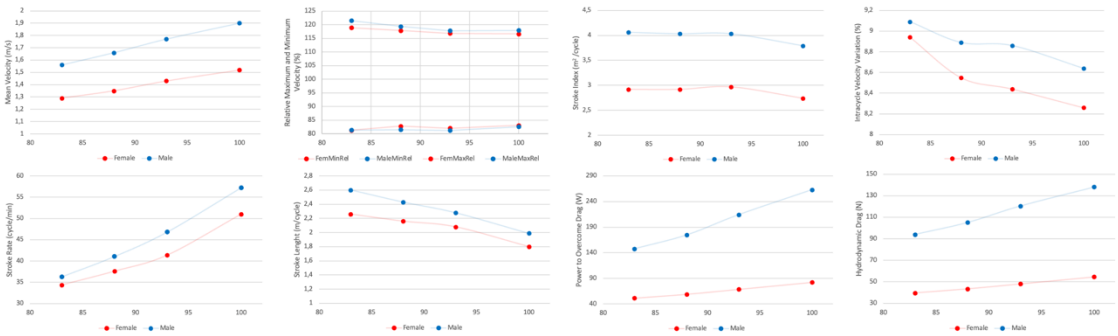


Figure 1. Swimmers mean velocity, relative maximum and minimum velocities, stroke index, intracycle velocity variation, stroke rate, stroke length, power to overcome drag and hydrodynamic drag across paces.

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27. Comparison of kinematics and power to overcome drag between competitive triathletes and swimmers

Assíria-Costa, L.[1], Machado, M.L.[1], Garrido, N.D.[2], Santos, C.C.[2], & Costa, M.J.[1]

[1] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D) and Porto Biomechanics Laboratory (LABIOMEP-UP), Faculty of Sport, University of Porto, Portugal
[2] Department of Sport Sciences, Exercise and Health, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal

*Corresponding author: N/A

The speed of triathletes and the energy they save during the swimming stage of a triathlon race can determine the following disciplines [1]. Studies have shown that the power generated by thrust forces while swimming closely matches the power needed to overcome drag forces [2]. So, it is fair to question if competitive triathletes produce the same amount of power as swimmers, allowing them to be more hydrodynamic and technically efficient before taking the next disciplines of the race. This study aimed to compare kinematics and power to overcome drag between competitive triathletes and swimmers. A total of 18 participants, including eight triathletes (35.85 ± 10.13 years) and 10 swimmers (21.48 ± 4.32 years) affiliated with their specific National Federations, performed 2 x 25 m maximal efforts at front crawl, reproducing the velocity perturbation method [3]. Measurements were made of velocity at 25 m (v@25), stroke rate (SR), stroke length (SL), stroke index (SI), active drag (D_a), active drag coefficient (CD_a) and power to overcome drag force (Wd). A *t*-test for independent samples was computed to verify differences between triathletes and swimmers, using Cohen's d (d) as an effect size measure. The relationship between Wd and v@25 was calculated through the simple linear regression model using the coefficient of determination (R^2). Higher values were observed in swimmers for the majority of the variables, except for the SR and CD_a (Table 1). A significant and moderate relationship existed between Wd and v@25 ($R^2 = 0.46$, $p < 0.001$). Triathletes remain less skillful in technique and less hydrodynamic than swimmers, translating into a lower power to overcome drag force. This power output has a significant relationship with high swimming velocities, which may require triathletes to work on their technique to transfer power to the water more effectively in order to swim faster.

Table 1. Comparison of kinematic and hydrodynamic variables between triathletes and swimmers.

	Triathletes	**Swimmers**	**p**	**d**
v@25 ($m \cdot s^{-1}$)	1.38 ± 0.14	1.75 ± 0.07	0.009	0.31
SR (Hz)	0.85 ± 0.12	0.92 ± 0.07	0.134	0.70
SL (m)	1.65 ± 0.17	1.92 ± 0.09	<0.001	1.96
SI ($m^2 \cdot s^{-1}$)	2.28 ± 0.34	3.35 ± 0.16	<0.001	4.00
D_a (N)	31.06 ± 10.37	51.80 ± 22.55	0.029	1.08
CD_a (dimensionless)	0.38 ± 0.09	0.39 ± 0.17	0.903	0.07
Wd (W)	43.66 ± 17.41	91.02 ± 40.69	0.007	1.38

v25, velocity of 25 m; SR, stroke rate; SL, stroke length; SI, stroke index; D_a, active drag; CD_a, active drag coefficient; Wd, power to overcome drag.

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28. Short vs long course swimming: analyzing the 1500 m performance differential in open water and pool specialists

Pimentel, M.[1], Fernandes, R.J.[1], Carvalho, D.[2], Santos, C.C.[3], & Costa, M.J.[1]

[1] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D) and Porto Biomechanics Laboratory (LABIOMEP-UP), Faculty of Sport, University of Porto, Portugal
[2] Research Center for Physical Activity, Health and Leisure (CIAFEL), University of Porto, Portugal
[3] Higher Education School, Polytechnic of Coimbra, Portugal

*Corresponding author: N/A

Race analysis in swimming has been an important tool for understanding performance behavior within and between competitions [1]. Regularly, swimming performances are different when short or long course pools are considered [2]. However, it remains unclear if different swimming specialists are affected similarly when competing in these conditions. This study aimed to analyse the 1500 m swimming performance differential in open water and pool swimmers while competing in short and long course pools. Official race times in the 1500 m freestyle event from 20 open water specialists (OWS; 10 males: 20.60 ± 5.59 years and 10 females: 20.50±3.41 years) and 20 pool specialists (PS; 10 males: 18.80 ± 2.44 years and 10 females: 20.60 ± 4.59 years) who participated in the last two years at the Long Distance National Championships and in the National Swimming Championships were retrieved from an open access website (swimrankings.net). The percentage of variation (Δ, %) for individual times between short and long course pools was estimated. A *t*-test for dependent and independent samples was computed to verify differences in performance between the pool's type or swimmers' specialization, respectively. Cohen's d (d) was selected as an effect size measure. The 1500 m performance was better in the short than in the long course pool for both male (PS, -30.79 ± 20.78 s; OWS, -26.53 ± 14.90 s) and female (PS, -17.56 ± 11.21 s; OWS, -19.57 ± 18.43 s) swimmers regardless of their specialization. No differences were observed between PS and OWS when a specific pool type was considered (Table 1). The 1500 m freestyle performance is expected to be better when swimming in a short course pool (similarly to other swimming events). Since this fact is independent of the swimmers' specialization (pool or open water competitions), the amount of open water training does not compromise performance in pool conditions.

Table 1. The 1500 m performance differential between PS and OWS in short and long course pools.

	Short course	Long course	Δ	p	d
Males					
1500_{PS} (s)	969.24 ± 37.00	1000.03 ± 33.90	3.21	0.001	0.87
1500_{OWS} (s)	941.39 ± 20.78	967.92 ± 20.14	2.83	< 0.001	1.30
Females					
1500_{PS} (s)	1041.35 ± 49.92	1058.90 ± 50.13	1.69	< 0.001	0.35
1500_{OWS} (s)	1044.92 ± 41.94	1064.49 ± 35.20	1.91	0.008	0.51

PS, pool specialists; OWS, open water specialists.

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29. Is there any relationship between trunk incline and lower limbs' kinematics in non-expert swimmers during front crawl swimming?

Machado, M.[1], Piserchia, P.[2], Hamaoui, A.[2], Vilas-Boas, J.P.[1], Santos, C.C.[1,3], & Costa, M.J.[1]

[1] Center of Research, Education, Innovation and Intervention in Sport (CIFI2D) and Porto Biomechanics Laboratory (LABIOMEP), Faculty of Sport, University of Porto, Porto, Portugal
[2] Faculty des Sciences du Sport, Univesity Paris-Saclay, France
[3] Department of Sport Sciences, Exercise and Health, University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal

*Corresponding author: N/A

Trunk incline (TI) is considered a determining factor for hydrodynamic resistance. It can be influenced by swimming technique expressed by the movements of the different body segments, where the lower limbs have a key role (Kadi et al., 2024). While this topic is clear in competitive swimmers (Zamparo et al., 2009), the research on non-expert swimmers remains scarce. This study examined the relationship between the TI and the lower limb's kinematics of non-expert swimmers during front crawl swimming. Eighteen male participants (19.22±1.11 years old, 75.32±7.89 kg body mass, and 1.78±4.92 m height) performed 2 x 25 m front crawl at maximum intensity. The performances were recorded in the sagittal plane using a pair of cameras (GoPro 6, USA; 120 Hz), then imported to a video annotation software (Kinovea, v. 0.9.5) to analyse two consecutive swimming cycles. Kinematical analysis allowed to assess TI (in °), swimming velocity (v, in $m \cdot s^{-1}$), maximum knee angle (KneeMax, in °), minimum knee angle (KneeMin, in °), knee range of motion (KneeRoM, in °), knee angular velocity (KneeV in $° \cdot s^{-1}$), overall kicking duration (Dur, in s), propulsion phase duration (Prop, in s) and recovery phase duration (Rec, in s). Pearson's correlation coefficient (r) was used to verify the relationship between the variables under analysis, with the significance level set at $p \leq 0.05$. The average values for the variables analyzed were: TI = 15.64±3.16 °; v = 1.51±0.14 $m \cdot s^{-1}$; KneeMax = 178.31±2.68 °; KneeMin = 121.49±11.45 °; KneeRoM = 56.83±10.83 °; KneeV = 149.73±42.75 $° \cdot s^{-1}$; Dur = 0.41±0.14 s; Prop = 0.18±0.07 s; Rec = 0.22±0.07 s. A negative association was found between the TI and v (r = -0.64, p = 0.002), KneeMin (r = -0.68, p = 0.002) and KneeRoM (r = -0.74, p = 0.001). The results indicate that a greater TI in non-expert swimmers can be a consequence of a weaker knee action which negatively affects v. This demonstrates that the contribution of the knee movement is crucial to maintain a horizontal position and should be a constant focus of attention during the teaching process in swimming.

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30. Swimming entry times and best performance in Men's 50 and 100m freestyle in World Championships between 2019 and 2024

Venâncio, T.[1,2,3,4], Costa, M.J.[5], Santos, C.C.[6,7], Vilarigues, I.[2], Antúnez, A.[2], & Espada, M.C.[1,3,8,9,10]

[1] SPRINT Sport Physical Activity and Health Research & Innovation Center, Centro de Investigação e Inovação em Desporto Atividade Física e Saúde (SPRINT), Portugal
[2] Training Optimization and Sports Performance Research Group (GOERD), Faculty of Sport Science, University of Extremadura, Espanha
[3] Life Quality Research Centre (CIEQV), Instituto Politécnico de Setúbal, Portugal
[4] Biosciences Higher School of Elvas, Polytechnic Institute of Portalegre, Portugal
[5] Centre of Research, Education, Innovation, and Intervention in Sport (CIFI2D) and Porto Biomechanics Laboratory (LABIOMEP-UP), Faculty of Sport, University of Porto, Portugal
[6] Higher Education School, Polytechnic of Coimbra, Portugal
[7] Department of Sport Sciences, Higher Institute of Educational Sciences of the Douro (ISCE-Douro), Penafiel, Portugal
[8] Instituto Politécnico de Setúbal, Escola Superior de Educação, Portugal
[9] Comprehensive Health Research Centre (CHRC), Universidade de Évora, Portugal
[10] Centre for the Study of Human Performance (CIPER), Faculdade de Motricidade Humana, Universidade de Lisboa, Portugal

*Corresponding author: N/A

In world-class swimming competitions, entry times (et) are currently one of the most important indicators that coaches and swimmers pay attention. It is a way to know the ability of their opponents and, if necessary, adjust competition strategies (santos et al., 2023). This study aimed to analyze the male's et and best performances (bp) in the 50 and 100m freestyle (fr) events and compare those between four editions of world championships (wc). Only swimmers with b qualifying standards in both events were considered resulting in 398 individual performances to be considered among the four wc editions (50 fr, n = 204; 100 fr, n = 194). The data was retrieved from the official open-access websites of omega and fina/world aquatics. a paired sample t-test was used to compare et and bp according to the four wc and the cohen's d was selected as the standardized effect size (es). A one-way anova was used to verify the time effect and the eta squared (η^2) was selected as an es measure. No differences were found when analysing the effect of time across the four wc in men's 50 and 100m fr ($p>0.05$, $\eta^2 <0.04$, in all cases). When comparing the et and the bp values in the four wc, the bp was higher (slower swimming time) than et. the bp consistently improved from 2019 to 2024 in both 50 and 100 m fr, contrary to the et. the findings of this study suggest that coaches and swimmers should consider specific strategies for international-level events qualification since our findings highlight that bp were slower compared to et. Moreover, race strategy for performance enhancement during wc competitions should be considered by coaches and swimmers.

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31. Progression and variability of Men's 800 and 1500m freestyle performance throughout four World Championships editions

Vilarigues, I.[1], Santos, C.C.[2,3], Costa, M.J.[4], Venâncio, T.[1,5,6,7], & Espada, M.C.[5,6,8,9,10]

[1] Training Optimization and Sports Performance Research Group (GOERD), Faculty of Sport Science, University of Extremadura, Espanha
[2] Higher Education School, Polytechnic of Coimbra, Portugal
[3] Department of Sport Sciences, Higher Institute of Educational Sciences of the Douro (ISCE-Douro), Penafiel, Portugal
[4] Centre of Research, Education, Innovation, and Intervention in Sport (CIFI2D) and Porto Biomechanics Laboratory (LABIOMEP-UP), Faculty of Sport, University of Porto, Portugal
[5] SPRINT Sport Physical Activity and Health Research & Innovation Center, Centro de Investigação e Inovação
em Desporto Atividade Física e Saúde (SPRINT), Portugal
[6] Life Quality Research Centre (CIEQV), Instituto Politécnico de Setúbal, Portugal
[7] Biosciences Higher School of Elvas, Polytechnic Institute of Portalegre, Portugal
[8] Instituto Politécnico de Setúbal, Escola Superior de Educação, Portugal
[9] Comprehensive Health Research Centre (CHRC), Universidade de Évora, Portugal
[10] Centre for the Study of Human Performance (CIPER), Faculdade de Motricidade Humana, Universidade de Lisboa, Portugal

*Corresponding author: N/A

In swimming, most training plans are designed to excel in a single competition or a group of competitions (Mujika et al., 2002). This study aimed to analyse the progression and variability of swimming performance in the 800 and 1500m men's freestyle (FR) events in the last four editions of FINA/World Aquatics World Championships (WC). Entry times (ET) and best performances (BP) of swimmers who qualified with FINA/World Aquatics b standards (800m, n=128; 1500m, n=107) to Guangzhou 2019 (WC1), Budapest 2022 (WC2), Fukuoka 2023 (WC3) and Doha 2024 (WC4) were retrieved from the official open-access website of OMEGA. A paired sample T-test was used to compare ET and BP within the four WC and Cohen's d was selected as the standardized effect size (ES). A one-way ANOVA was used to verify the progression between competitions of the time effect and the eta squared (η^2) was selected as ES measure. No differences were found when analysing the effect of time across the four WC in ET and BP for both swimming events ($p>0.05$, $\eta^2 <0.04$). When comparing ET and BP values at each WC in all editions and swimming distances, the ET was lower compared to BP (i.e., faster swimming performance). However, ET and BP were similar in WC3 ($p=0.082$) for FR800 and WC2 ($p=0.112$) and WC3 ($p=0.162$) for FR1500. The ET of FR800 systematically improved from 2019 to 2024, but this was not observed considering the FR1500, with stabilization from WC2 to WC4. Considering the BP, no consistent improvement was found throughout the WC editions in both long-distance events. These findings suggest that coaches and swimmers should consider specific strategies when training for the FR800 and FR1500m, aiming to guarantee presence in WC swimming events, since BP were always slower compared to ET.

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32. Swimming entry times and best performances in Women's 50 and 100m freestyle in World Championships between 2019 and 2024

Venâncio, T.[1,2,3,4*], Costa, M.J.[5], Santos, C.C.[6,7], Vilarigues, I.[2], & Espada, M.C.[1,3,8,9,10]

[1] SPRINT Sport Physical Activity and Health Research & Innovation Center, Centro de Investigação e Inovação em Desporto Atividade Física e Saúde (SPRINT), Portugal
[2] Training Optimization and Sports Performance Research Group (GOERD), Faculty of Sport Science, University of Extremadura, Espanha
[3] Life Quality Research Centre (CIEQV), Instituto Politécnico de Setúbal, Portugal
[4] Biosciences Higher School of Elvas, Polytechnic Institute of Portalegre, Portugal
[5] Centre of Research, Education, Innovation, and Intervention in Sport (CIFI2D) and Porto Biomechanics Laboratory (LABIOMEP-UP), Faculty of Sport, University of Porto, Portugal
[6] Higher Education School, Polytechnic of Coimbra, Portugal
[7] Department of Sport Sciences, Higher Institute of Educational Sciences of the Douro (ISCE-Douro), Penafiel, Portugal
[8] Instituto Politécnico de Setúbal, Escola Superior de Educação, Portugal
[9] Comprehensive Health Research Centre (CHRC), Universidade de Évora, Portugal
[10] Centre for the Study of Human Performance (CIPER), Faculdade de Motricidade Humana, Universidade de Lisboa, Portugal

*Corresponding author: tiagovenancio@ipportalegre.pt

In swimming, to qualify for demanding competitions such as World Champions (WC), athletes usually compete in a wide spectrum of competitions within a year[1]. Moreover, there is a research gap on whether major competitions are still a place to excel if entry times (ET) are considered the starting point for performance progression analysis[2]. The present study aimed to analyze the women's ET and best performances (BP) in the 50 and 100m freestyle (fr) events and compare those between four editions of WC. Only swimmers with B qualifying standards in both events were considered resulting in 284 individual performances to be considered among the four WC editions (50m fr, n = 160; 100m fr, n = 124). The data was retrieved from the official open-access websites of OMEGA and FINA/World Aquatics. A paired sample t-test was used to compare ET and BP according to the four WC and the Cohen's d was selected as the standardized effect size (ES). A one-way ANOVA was used to verify the time effect and the eta squared (η^2) was selected as an ES measure. Differences between ET and BP in the women's 50 and 100m fr events with minor variations across the WC were found. Overall, ET were consistently faster than BP in both events (mean difference 95% confidence interval from 2019 to 2024 in 50m fr = -0.19; -0.36; -0.19; -0.20 and in 100m fr = - 0.23; -0.28; -0.24; -0.35). However, the analysis of the time effect (ANOVA) across the four WCs showed no significant changes in ET or BP for either event ($p>0.199$), with very small ES ($\eta^2 \leq 0.03$). These findings suggest that WC are not competitive events to perform better when considering the ET. While a BP stability should be expected across several WC editions, some individual variations in performance by event can occur.

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33. Progression and variability of Women's 800 and 1500m freestyle performance throughout four World Championships editions

Vilarigues, I.[1*], Santos, C.C.[2,3], Costa, M.J.[4], Venâncio, T.[1,5,6,7], & Espada, M.C.[5,6,8,9,10]

[1] Training Optimization and Sports Performance Research Group (GOERD), Faculty of Sport Science, University of Extremadura, Espanha
[2] Higher Education School, Polytechnic of Coimbra, Portugal
[3] Department of Sport Sciences, Higher Institute of Educational Sciences of the Douro (ISCE-Douro), Penafiel, Portugal
[4] Centre of Research, Education, Innovation, and Intervention in Sport (CIFI2D) and Porto Biomechanics Laboratory (LABIOMEP-UP), Faculty of Sport, University of Porto, Portugal
[5] SPRINT Sport Physical Activity and Health Research & Innovation Center, Centro de Investigação e Inovação em Desporto Atividade Física e Saúde (SPRINT), Portugal
[6] Life Quality Research Centre (CIEQV), Instituto Politécnico de Setúbal, Portugal
[7] Biosciences Higher School of Elvas, Polytechnic Institute of Portalegre, Portugal
[8] Instituto Politécnico de Setúbal, Escola Superior de Educação, Portugal
[9] Comprehensive Health Research Centre (CHRC), Universidade de Évora, Portugal
[10] Centre for the Study of Human Performance (CIPER), Faculdade de Motricidade Humana, Universidade de Lisboa, Portugal

*Corresponding author: iuri.vila@hotmail.com

Progression and variability of swimming performance to and within the major competitions have been topics of interest and debate over the years[1], with a ~1% performance improvement within the year being necessary to be part of a major event[2]. This study aimed to analyse the progression and variability of swimming performance in the 800 and 1500m women's freestyle events in the last four FINA/World Aquatics World Championships (WC) editions. The entry times (ET) and best performances (BP) of swimmers who qualified with B standards (800m, n=105; 1500m, n=100) of Guangzhou 2019 (WC1), Budapest 2022 (WC2), Fukuoka 2023 (WC3) and Doha 2024 (WC4) were retrieved from the official open-access website of OMEGA. A paired sample T-test was used to compare ET and BP within the four WC and Cohen's d was selected as the standardized effect size (ES). A one-way ANOVA was used to verify the progression between competitions of the time effect and the eta squared (η^2) was selected as ES measure. Results: No differences were found when analysing the effect of time across the four WC in ET and BP for both swimming events ($p>0.05$, $\eta^2<0.04$). ET were consistently lower than BP values, indicating faster qualification times than swimming performance within all the WC. Moreover, no consistent patterns or similarities were observed across WC editions in both swimming distances. These findings suggest that coaches and swimmers should consider specific strategies when training for the 800 and 1500m to guarantee presence in WC swimming events since BP were always slower than ET.

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34. Monitorização das características biomecânicas de um dueto de natação artística ao longo de um macrociclo

Pinto, S.[1], Fernandes, R.J.[1], Santos, C.C.[1,2], & Costa, M.J.[1]

[1] CIFI2D e LABIOMEP, Faculdade de Desporto, Universidade do Porto
[2] ISCE Douro, Penafiel

*autor correspondente: N/A

As respostas fisiológicas e biomecânica são aspetos fundamentais para maximizar o potencial dos praticantes de natação artística [1]. No caso da competição de dueto, onde a semelhança corporal tem implicações na estética visual da apresentação, suspeita-se que a igualdade técnica e a produção força poderão criar uma maior uniformidade dos movimentos, resultando numa classificação mais elevada em competição. Foi objetivo deste estudo verificar a evolução nas características biomecânicas de um dueto de natação artística ao longo de um macrociclo de treino. Duas nadadoras (17,5 ± 0,5 anos de idade) integrantes do Projeto Olímpico Los Angeles 2028 foram avaliadas em dezembro de 2023 (M1) e em abril de 2024 (M2) no que se refere à capacidade de produção de força nas ações técnicas de remada americana e *kick pull*. As nadadoras realizaram ambas as ações em esforço máximo (20") e a uma distância de 5 m da parede, permanecendo conectadas a um sistema de avaliação de força (Swim-Spektro, Talamonti, Italy) que permitiu determinar as forças máxima (Fmáx, N) e média (Fméd, N). Na mesma sessão, avaliou-se a qualidade de execução de cinco espargatas em formato livre (intensidade máxima). As nadadoras foram gravadas no plano sagital por um par de câmaras (GoPro 6, USA; 120 Hz) para posterior determinação da velocidade angular (ω, rad/s) com recurso ao software Kinovea (v. 0.9.5). A coreografia padrão do dueto foi repetida em contexto competitivo nos dois momentos de avaliação. Ao longo do macrociclo as nadadoras foram sujeitas a treino individualizado de acordo com os resultados obtidos no M1. Os valores individuais de todas as variáveis e a percentagem de variação (Δ, %) entre nadadoras foram determinados em ambos os momentos. A tabela 1 apresenta os valores individuais e respetivas variações em cada momento de avaliação. Verificou-se tendência para uma evolução na Fmáx e Fméd da remada e do *kick pull*, existindo uma aproximação da nadadora 2 em relação à nadadora 1. Foi notório um aumento na velocidade de execução das espargatas com uma ligeira aproximação entre ambas. A classificação da coreografia em competição aumentou de 168,9943 para 190,7183 pontos.

Tabela 1. Valores individuais e variações entre nadadoras ao longo do macrociclo.

	Momento 1			**Momento 2**		
	N1	**N2**	**Δ (%)**	**N1**	**N2**	**Δ (%)**
Fmáx *kick pull* (N)	656,54	396,51	39,60	704,67	533,64	24,27
Fméd *kick pull* (N)	187,04	102,72	45,08	193,88	137,54	29,06
Fmáx remada (N)	196,07	163,94	16,39	205,6	153,35	25,41
Fméd remada (N)	84,18	65,95	21,66	83,71	75,39	9,94
TEspargatas (s)	1,49	1,77	-18,79	1,22	1,45	-18,85
vEspargatas (rad/s)	4,22	3,55	15,91	5,15	4,35	15,53

N1, nadadora 1; N2, nadadora 2; Fmáx, força máxima; Fméd, força média, T, tempo; v, velocidade.

O treino realizado no referido macrociclo foi benéfico para a evolução das características biomecânicas do dueto à semelhança do reportado na literatura [2]. A introdução de uma sessão adicional de treino de força parece ter permitido que a nadadora 2 se tenha aproximado da nadadora 1 em perfil de força e de velocidade de execução. Numa perspetiva de dueto,

verificou-se uma tendência de aproximação dos aspetos técnicos e de força, resultado numa ação mais coordenada e eficiente, traduzindo-se numa melhor prestação competitiva.

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35. Relação entre parâmetros biomecânicos e a inclinação do tronco em nadadores não experts

Machado, M.[1], Piserchia, P.[2], Hamaoui, A.[2], Vilas-Boas, J.P.[1], Santos, C.C.[1,3,4], & Costa, M.J.[1]

[1] CIFI2D e LABIOMEP, Faculdade de Desporto, Universidade do Porto
[2] Universidade Paris-Saclay, França
[3] ISCE Douro, Penafiel
[4] CIDESD, Vila Real, Portugal

*autor correspondente: N/A

A inclinação do tronco (IT) é vista como um fator determinante para a resistência hidrodinâmica e pode ser influenciada pela técnica de nado e pela força produzida pelos diferentes segmentos corporais [1]. Embora este seja um tópico esclarecido em nadadores de competição, os estudos com nadadores não experts são escassos. Foi objetivo deste estudo verificar a relação existente entre o perfil cinemático e cinético de nadadores não experts e a IT durante o nado de crol. Dezoito sujeitos do sexo masculino (19,22±1,11 anos de idade, 75,32±7,89 kg de massa corporal e 1,78±4,92 m de altura) realizaram 1 x 25 m crol à máxima intensidade. As execuções foram gravadas no plano sagital por um par de câmaras (GoPro 6, USA; 120 Hz) permitindo posteriormente a determinação da IT (°) com recurso ao software Kinovea (v. 0.9.5). Do ponto de vista cinemático foram determinadas a velocidade de nado (v, $m \cdot s^{-1}$) e a frequência gestual (FG, Hz) para posterior estimativa da distância de ciclo (DC, m) e do índice de nado (IN, $m^2 \cdot s^{-1}$). No domínio da cinética aplicou-se um teste de nado amarrado (20 s) com ação exclusiva dos membros inferiores. Os sujeitos foram conectados a um sistema integrado de avaliação de força (Swim-Spektro, Talamonti, Itália) permitindo determinar a força máxima (Fmax, N) e força média (Fméd, N). Recorreu-se ao coeficiente de correlação de Pearson (r) para verificar a relação entre as variáveis em análise determinando-se o nível de significância como $p \leq 0,05$. Os valores médios para as variáveis em análise foram: IT = 15,64±3,16 °; v = 1,51±0,14 $m \cdot s^{-1}$; FG = 0,88±0,12 Hz; DC = 1,74±0,29 m; IN = 2,66±0,60 $m^2 \cdot s^{-1}$; Fmax = 130,31±21,78 N; Fméd = 61,19±12,78 N. Verificou-se uma associação negativa da IT com a v, IN e Fméd (Figura 1).

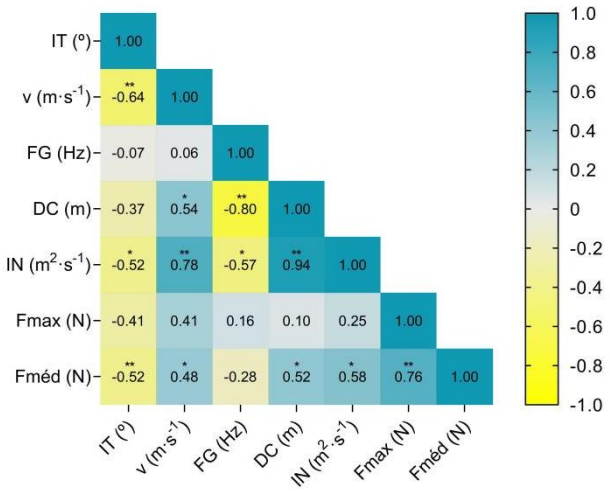


Figura 1. Matriz de correlações entre a IT e as restantes variáveis no domínio cinemático e cinético. IT, inclinação do tronco; v, velocidade de nado; FG, frequência gestual; DC, distância de ciclo IN, índice de nado; Fmax, força máxima; Fméd, força média. * $p \leq 0.05$, **, $p \leq 0.01$

Os resultados do presente estudo indicam que uma maior IT afeta a v e consequentemente a eficiência do nado (relação negativa com o IN). Isto parece ser consequência de uma fraca propulsão dos membros inferiores, tal como comprovado pela relação negativa existente entre a Fméd e a IT. Este facto já foi verificado em nadadores competitivos [2], onde o contributo dos membros inferiores na redução da IT parece rondar os 13% [3]. Isto demonstra que a ação dos membros inferiores é crucial e deve ser foco de otimização constante durante o processo de ensino.

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36. Different type of gloves used in water fitness promotes similar acute physiological responses: a pilot study in older men

Carrijo, V.[1], Farinha, C.[2], Kanitz, A.[3], Costa, M.J.[1], & Santos, C.C.[1,4]

[1] CIFI2D and LABIOMEP, Faculty of Sport, University of Porto
[2] SPRINT, Polytechnic Institute of Castelo Branco
[3] ESEFID, Federal University of Rio Grande do Sul
[4] ISCE Douro, Penafiel

*Corresponding author: N/A

The use of buoyant and resistant equipment in water fitness sessions elicits a more intense physiological response [1,2]. However, it remains unknown whether different materials (e.g., rubber, neoprene) that compose such kind of equipment lead to different physiological responses during a water fitness exercise. Therefore, this study aimed to analyze and compare the acute physiological response of older men while using different gloves in a water fitness exercise. Four older men (74.2 ± 5.6 years of age and 79.2 ± 9.4 kg of body mass) were recruited from a local swimming center for two testing sessions (48 h apart). After a 3-minute warm-up, the participants were instructed to perform the upper limbs' horizontal adductions/abductions for 5-minute to reach the cardiovascular steady state. Two pairs of gloves with different materials were used (one pair for each session): (i) rubber membrane (Aqua Membrane, medium, Golfinho Sports, Portugal) and (ii) neoprene membrane (Neoprene "Golfinho", small, Golfinho Sports, Portugal). The cadence was set at 120 bpm and controlled by a metronome (Korg, MA-30, Tokyo, Japan). The physiological response was assessed using the mean heart rate (HR, bpm), systolic blood pressure (SBP, mmHg), double product (DPr = HR x SBP), blood lactate concentration ([La−], mmol/L), and rate of perceived exertion (RPE) [1]. The mean heart rate was assessed at rest (pre- and post-exercise) and during the exercise, and data were also analysed according to the percentage (%) of the predicted maximal theoretical heart rate (HRmax = 208 – 0.7 x age). The [La−], RPE (Borg 6-20 scale), SBP and DPr were collected immediately after the exercise. A Wilcoxon signed-rank test was used to compare all physiological responses when using the different gloves type. The effect size (ES) was calculated as $r = Z/\sqrt{N}$ and the level of statistical significance was set at $p \leq 0.05$. The physiological comparison between the two types of gloves is shown in Table 1.

Table 1. Descriptive and inferential analysis for acute physiological responses according to the glove's type.

Variables	Moment	Gloves type		*p*	ES
		Rubber	Neoprene		
Mean HR (bpm)	Pre-exercise	78.01±14.90	75.77±16.55	0.273	0.55
	Exercise	101.94±13.85	94.69±13.76	0.068	0.91
	Post-exercise	82.46±14.42	75.77±13.97	0.144	0.73
Mean HR (%)	Pre-exercise	49.98±9.27	48.57±10.46	0.273	0.55
	Exercise	65.42±9.35	60.73±8.90	0.068	0.91
	Post-exercise	52.87±9.11	48.59±8.94	0.144	0.73
SBP (mmHg)	Post-exercise	144.00±36.51	139.50±22.07	0.465	0.71
DPr	Post-exercise	14612.75±3808.19	13282.12±3205.27	0.273	0.55
$[La^-]$ (mmol/L)	Post-exercise	5.42±0.85	5.82±1.24	1.000	0.00
RPE	Post-exercise	11.75±0.96	12.25±0.96	0.157	0.71

ES, effect size; HR, heart rate; SBP, systolic blood pressure; DPr, double product; [La−], blood lactate concentration; RPE, rate of perceived exertion.

Similar physiological responses were found when older men used rubber and neoprene gloves. However, rubber gloves showed a tendency to increase mean HR during exercise accompanied by a greater DPr and lower RPE after exercise. This suggests that a higher cardiovascular demand is probably induced when using this type of gloves, but it may be underlying to an inter-individuality phenomenon. So, studies on larger samples are needed to understand better the effect of different materials on acute physiological responses in this population.

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37. Swimming performance progression in men's and women's 400 m individual medley events

Paiva, E.[1], Forte, P.[1], Costa, M.J.[2], & Santos, C.C.[1,2,3]

1 ISCE Douro, Penafiel
2 CIFI2D and LABIOMEP, Faculty of Sport, University of Porto
3 CIDESD, Vila Real

*Corresponding author: N/A

The individual medley (IM) is a unique event as it incorporates all four different swimming strokes into the 200 m or 400 m distances when swum in a long course pool (1). At least for Men's 200IM, positive improvements between heats and semifinals seem to be crucial to reaching the final (2), but those seem far to get performances similar or better to their entry times. Since the 400IM is characterized as an event with few rounds (just heats and finals), an in-depth analysis of round-to-round progression is necessary. Thus, this study aimed to compare performance progression and variability between entry times and all rounds in Men's and Women's 400IM at the 2022 FINA World Championships. The entry times (Et) and official race times for the heats (H) and finals (F) of the swimmers who participated in the 400IM at the 2022 FINA World Championships were extracted from the OMEGA and FINA official websites and then converted from min to s. The overall (male, n = 28; female, n = 18) and finalists (n = 8 for each event) swimmers were considered for further analysis. A dependent t-test or a repeated measures ANOVA followed by the Bonferroni post-hoc was conducted to analyze the round-to-round performance variation, as well as the effect size (ES) for each test. The percentage of improvement (%IMP) between rounds was calculated with negative/positive values evidencing a race time increase/decrease, respectively. Differences between Et-H (overall) were found in Men's (Et, 255.33±5.35 s vs H, 258.37±6.71 s; ES = 0.50) and Women's 400IM (Et, 283.03±14.27 s vs H, 287.28±13.76 s; ES = 0.30) (Table 1) with both having a negative progression between Et-H (~1 to 1.5%). Regarding the finalist group, a round effect was found in Women's 400 IM (p = 0.028; ES = 0.40), whereas performance in Men's 400IM remained similar between all rounds (p = 0.489; ES = 0.10). However, a similar %IMP trend was shown in Men's and Women's finalists as a negative and positive %IMP was found between Et-H and H-F, respectively.

Table 1. Round-to-round progression of overall and finalist in Men's and Women's 400IM event.

Event/Group	Et-H		H-F	
	p	%IMP	*p*	%IMP
Men's 400IM				
Overall (n = 28)	<0.001	-1.16	-	-
Finalist (n = 8)	0.516	-0.38	1.000	0.39
Women's 400IM				
Overall (n =18)	<0.001	-1.49	-	-
Finalist (n = 8)	0.021	-1.23	0.971	0.38

%IMP, percentage of performance improvement; Et, entry; F, finals; H, heats; IM, individual medley

It has been reported that swimmers who participate in a major event are not able to reach their entry times during all rounds of the four competitive swimming strokes [3] as well as during the Men's 200IM event (2). This corroborates the results found in the present study as a negative %IMP was found between Et-H. Furthermore, as shown at the remaining events (2,3), positive improvements between H-SF were crucial in reaching the final of Men's and Women's 400IM at the 2022 FINA World Championships. Since intra-individual differences are expected at IM

events, future studies should understand the progression by dissecting the race into the four swimming strokes.

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TESES DE DOUTORAMENTO E DISSERTAÇÕES DE MESTRADO

TESES DE DOUTORAMENTO E DISSERTAÇÕES DE MESTRADO

1. Intracycle velocity variations in swimming: deeper analysis and new insights

Aléxia Alves Fernandes

Swimming performance may be optimised by reducing velocity variations and, consequently, energy expenditure, transforming the movement into as uniform as possible. The current thesis deeply analysed the intracycle velocity variation assessment and give new insights into its usefulness for swimming performance enhancement. A systematic scoping review identified the main gaps in the literature showing that 61% of the studies used the coefficient of variation to represent intracycle velocity variation. Swimmers of different competitive levels were evaluated in the four techniques at various paces, recording their displacement along 25 m with aerial and underwater cameras for 2D kinematic analysis. Intracycle velocity variation was assessed combined with other variability measures. Minimum and maximum velocities, stroke rate, length and index, phases duration and velocity, indexes of coordination and synchronization were the kinematical variables examined. Results showed that, although the coefficient of variation is a sensitive method for assessing velocity dispersion around the mean, it was unable to differentiate swimmers of varying competitive levels, except in butterfly. The relative power to velocity was proposed to overcome the intracycle velocity variation limitations, since it integrates the individual characteristics regarding the drag conditions. The power necessary to velocity variation increases in absolute magnitude but decreases in relative terms as mean velocity increases. It also enables to predict its effect on the swimmers performance. This variable revealed that butterfly and front crawl emerged as the swimming techniques that most effectively combined the ability to minimize drag with higher mean velocities. Breaststroke presented the highest mechanical demands, especially at higher intensities, reflecting its biomechanical complexity. This thesis offers comprehensive insights into the velocity variations in swimming and contributes to swimming performance enhancement.

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2. Breathing mechanics at different exercise intensity domains

Ana Sofia Mottini Monteiro

Understanding how the changes in breathing mechanics with exercise are reflected in biophysical responses is essential to interpret sports performance. It was implemented an intermittent incremental protocol until exhaustion according to the exercise mode: (i) in swimming, 200 m steps with 0.05 m·s-1 velocity increments were performed on an indoor 25 m swimming pool, (ii) in running, 800 m steps with 1 km·h-1 velocity increments were performed on an outdoor track field and (iii) in cycling, 3 min steps with 25 W increments were performed on a smart trainer system. All the steps were separated by 30 s passive rest intervals. In some studies, a 100 m, 400 m and 1 min maximal bouts were added at the end of the protocol (respectively). Results pointed out the repeatability of the most frequently assessed ventilatory, metabolic and biomechanical variables during the incremental protocol, well characterizing the swimmers physiological condition at the evaluation moment. When using a respiratory snorkel, especially at higher intensities, swimmers seem to adopt a different breathing pattern, losing the imposed synchronization with stroke rate (due to face immersion and restricted ventilation). Given the advantages of assessing oxygen uptake through backward extrapolation and the analysis of its off-transient kinetics, the development and validation of VO2FITTING (an open-source software to characterize oxygen uptake kinetics during continuous exercise) for postexercise data was conducted. Regarding the bioenergetic profiles, the aerobic and anaerobic metabolisms have different behaviours and relative contributions along the velocities in the three exercise modes. When considering low to extreme velocities, exercise economy is better described by an exponential model. With the increase in intensity and energy demand, there is a constant adaptation of physiological responses and technical patterns, reflecting the close interaction between these mechanisms. In the three exercise modes, the ventilation rise along the intensities seems to be mainly caused by increases in respiratory frequency, while tidal volume was maintained. This analysis allowed a deeper understanding of performance depending on the intensity, improving training evaluation and prescription.

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3. Energetics, kinematics and active drag in the breaststroke swimming technique

Miriam Natacha Rodrigues Alves

Swimming performance depends largely on energetic demands, which are shaped by swimmers' biomechanical and motor strategies. Breaststroke presents unique biomechanical and physiological characteristics. While breathing patterns have been studied in the butterfly technique and front crawl, their effects in breaststroke remain underexplored, despite the flexibility allowed by World Aquatics rules. The primary objective of this doctoral thesis was to compare and characterize two distinct breathing patterns, breathing every cycle and breathing every two cycles, in the breaststroke technique. Specifically, the research aimed to: (1) analyze and compare these breathing patterns through kinematic parameters of key reference points (hand, foot, head, and center of mass) across different movement planes, and (2) evaluate their effects on energy cost, efficiency, and active drag. Fifteen swimmers underwent a six-week intervention to learn the new breathing pattern. Subsequently, they performed a 5 × 200 m step test (with 0.05 $m \cdot s^{-1}$ increments and 30 seconds rest) under both breathing conditions, two 25 m all-out trials using the velocity perturbation method in each breathing pattern, and three maximal 25 m efforts in each breathing pattern. The results showed that: (i) breathing every two cycles in breaststroke was associated with higher values of key bioenergetic variables, including peak blood lactate concentration, peak oxygen uptake, total metabolic power output, and energy cost, particularly at moderate to high intensities; (ii) inter-individual variability was observed in swimmers' hydrodynamic and energetic responses to different breathing patterns in breaststroke; (iii) differences in kinematics (amplitudes, angles, velocities, fractal dimension, and intracycle variation of velocity) among the breathing patterns were minimal, with no clear superiority of one breathing pattern over the other; (iv) not breathing was associated with reduced vertical and horizontal head movement amplitudes; (v) this pattern also corresponded with the highest vertical foot velocity and greatest center of mass velocity in the swimming direction, suggesting potential biomechanical advantages; (vi) breathing every cycle enhanced hand efficiency and hand stabilization measures; (vii) breathing every two cycles improved feet stabilization and displacement; (viii) greater motor path stabilization was associated with lower energy cost; (ix) foot and total stabilization indices strongly related to foot displacement; and (x) breathing every cycle showed greater medio-lateral hand amplitude and lower minimum center of mass horizontal velocity. In conclusion, while some swimmers benefited from reduced breathing frequency, overall breaststroke technique was not systematically modified by the breathing pattern.

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4. The effect of water aerobics in adults and older adults in health-related variables: The importance of duration and intensity parameters

Luís Oliveira Brandão Faíl

Water aerobics has gained popularity, with its benefits increasingly recognized. However, there is limited information on the intensity and duration needed for optimal outcomes. This thesis explores the effects of varying intensities and durations of water aerobics on health-related variables in adults and older adults. To achieve this, the following steps were performed i) a systematic review with meta-analysis on the effects of water-based programs on the health and fitness of healthy adults and those with chronic diseases; ii) comparison of moderate versus high-intensity water aerobics (12 and 24 weeks) on muscle strength, anthropometry, lipid profile, blood pressure (BP), and quality of life (QoL); iii) analysis of the relationship between muscle strength gained after water aerobics and other factors including program intensity and duration, age, and baseline health-related variables; iv) analysis of the association between BP and lipid profile results obtained after water aerobics and factors like program intensity and duration, age, and initial health-related measurements. The findings indicated that i) few studies have assessed exercise intensity in water aerobics; ii) high-intensity water aerobics was more effective than moderate-intensity in improving lipid profile, fat mass, fat-free mass, diastolic BP, and physical QoL; iii) both durations of high-intensity water aerobics benefited diastolic BP, with greater effects after 24 weeks; iv) both programs improved muscular endurance after 12 and 24 weeks, with higher intensity related to better lower limb muscular endurance; v) psychological QoL improved after 12 weeks; vi) initial values of muscular endurance and age were related to upper limb muscular endurance and explosive strength outcomes, while initial body composition was associated with explosive strength; vii) changes in lipid profile were influenced by intensity, while diastolic BP was affected by program duration, and initial total cholesterol levels were positively associated with changes in systolic and diastolic BP. Overall, high-intensity water aerobics improves lipid profile, body composition, and physical QoL in adults and older adults. 24 weeks of this exercise also reduces diastolic BP. Water aerobics enhances muscular endurance regardless of intensity and duration. This thesis offers valuable insights for water aerobics instructors, recommending strategies to tailor intensity levels to individual needs.

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5. Kinetics of swimming: from tethered forces to active drag and force-velocity relationship

Maria Inês da Silva Lemos

Competitive swimming is one of the most popular sports worldwide, leading coaches and researchers to seek a deeper understanding of the factors that influence swimmers' performance. Among these, the role of hydrodynamic drag exerted on the swimmer's body stands out, in its components of active drag and passive drag. The present dissertation focused on two main objectives: (i) to investigate the influence of different perturbations on the determination of intracyclic drag variations in front crawl and butterfly techniques, using the small perturbation method, and (ii) to present the Intracyclic Drag Assessment Method (IDAM) as a novel approach aimed at quantifying intracyclic variations of active drag during front crawl swimming. Four swimmers, two at national level and two at Olympic level (one male and one female in each group), performed: (i) two 25 m sprints (front crawl and butterfly) to determine time, mean velocity, and stroke frequency; (ii) two tethered swimming tests lasting the same duration as the sprints and at the stroke frequency determined for each technique; (iii) two sets of five semi-tethered swimming tests, with perturbations of 5, 10, 15, 20, and 25% of the maximum force measured in tethered swimming for each technique. The results revealed negative drag values in the butterfly technique at the beginning and end of each stroke cycle, even at low levels of perturbation; therefore, the IDAM was only applied to the front crawl. This new method enabled the characterization of active drag throughout the entire front crawl stroke cycle, considering the specific kinematic pattern of each swimmer, despite further refinements being necessary in the future.

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6. Effects of a land and aquatic exercise-based program on pain and functional disability in patients with chronic low back pain

Joana Catarina Carvalho Borges

A dor lombar crónica é uma condição clínica que afeta de forma significativa a funcionalidade, o bem-estar emocional e a vida social dos indivíduos. Diversas estratégias terapêuticas são recomendadas para a sua gestão, destacando-se, o exercício físico, realizado tanto em meio terrestre como em meio aquático, como uma das mais eficazes. Assim, neste trabalho, realizámos inicialmente um protocolo de estudo randomizado controlado que procuraria comparar o efeito de um programa de exercício combinado aquático e terrestre com um programa de exercício aquático, em adultos com dor lombar crónica. Os resultados poderiam oferecer informações valiosas para a gestão da dor lombar crónica. Posteriormente, e com base no protocolo efetuado, desenvolvemos um estudo randomizado controlado, com os dois programas de exercício previamente descritos, ao longo de 8 semanas. Procurou-se avaliar o efeito na dor, incapacidade funcional, medo de movimento e mobilidade lombar. Adicionalmente, analisou-se o efeito dos programas de exercício nas mesmas variáveis após um período de destreino de 4 semanas. Os resultados demonstraram que ao final das 8 semanas, os dois programas de exercício contribuíram significativamente para a redução da dor, incapacidade funcional e medo do movimento, bem como para o aumento da mobilidade lombar. Ainda assim, o programa de exercício combinado aparentou ter resultados significativamente superiores comparativamente ao programa de exercício aquático na dor, incapacidade funcional e medo do movimento. Após as 4 semanas de destreino verificou-se que os participantes dos dois grupos aumentaram significativamente a dor, incapacidade funcional e medo do movimento e diminuíram a mobilidade lombar. Mais investigação deve ser desenvolvida considerando um período de destreino superior ao analisado.

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7. A Competência Aquática em crianças do pré-escolar, com e sem Perturbação do Neuro-desenvolvimento

Mariana Ferreira Velhinho

A competência aquática percecionada consiste no que o indivíduo acredita ser capaz de fazer em meio aquático, com base nas suas crenças e experiências anteriores. Por outro lado, a competência aquática real é o que na realidade o indivíduo sabe fazer. Objetivos: Avaliar a competência aquática, real e percecionada, de crianças com idades compreendidas entre os 3 e os 6 anos, com e sem alterações do neurodesenvolvimento. Compreender a relação entre a competência aquática percecionada e real das crianças com desenvolvimento típico. Metodologia: Neste estudo quantitativo transversal, descritivo e correlacional participaram 118 crianças com desenvolvimento típico e 8 crianças de desenvolvimento atípico, que frequentam aulas de natação. Para a avaliação foram utilizados a Escala Pictórica de Motricidade Aquática (EPMA) e o Inventário de Medição de Competência Aquática Infantil (IMCAI), para avaliar a competência aquática percecionada e a real, respetivamente. Resultados: No grupo típico as crianças do sexo feminino, as mais velhas e as da classe AMA +6 obtiveram melhores resultados no IMCAI. Foram encontradas correlações significativas entre o IMCAI, todas as suas áreas (motora, cognitiva e socioafetiva) e a EPMA. Relativamente ao grupo atípico, a aplicação da EPMA teve de ser personalizada, tendo sido utilizadas estratégias para maximizar o desempenho de cada criança. Conclusões: Crianças do sexo feminino, mais velhas e da classe AMA +6 têm uma melhor competência aquática real. Verificou-se uma correlação forte entre a competência aquática percecionada e real, das crianças com desenvolvimento típico. Mostrou-se necessária a adaptação da EPMA a populações especiais

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8. Comparação do perfil hidrodinâmico entre triatletas e nadadores competitivos

Lawinya Assíria Amorim Costa

Esta dissertação teve como objetivo avaliar os fatores biomecânicos que influenciam o desempenho na natação de triatletas, articulando uma revisão sistemática da literatura com um estudo experimental. A revisão revelou um predomínio de investigações centradas em variáveis cinemáticas, sobretudo em contextos com uso de traje isotérmico, ao passo que aspetos cinéticos e hidrodinâmicos permanecem pouco explorados. Para complementar essas lacunas, conduziu-se um estudo experimental com nadadores e triatletas competitivos, comparando parâmetros biomecânicos de natureza cinética. Os nadadores demonstraram superioridade técnica, evidenciada por maior comprimento e índice de braçada, velocidade de nado mais elevada e melhor aproveitamento da força aplicada. Em contrapartida, os triatletas apresentaram maiores níveis de arrasto passivo e menor potência para vencer o arrasto, revelando limitações técnicas específicas, mas também potencial de melhoria. As análises de correlação indicaram que, entre os triatletas, o desempenho em distâncias curtas e médias foi fortemente condicionado por variáveis hidrodinâmicas, sugerindo que intervenções bem direcionadas podem gerar ganhos significativos mesmo com menor volume de treino aquático. Nesse sentido, este trabalho contribui para o fortalecimento da biomecânica como um eixo estratégico na preparação técnica de triatletas e propõe caminhos concretos para a otimização do seu desempenho usando os valores de nadadores como referência.

Referência
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PROJETOS FINANCIADOS

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1. O Treinador em Portugal, Estudo de Caracterização do Treinador Português

Ser Treinador é desenvolver pessoas, equipas e o futuro do Desporto. Mas o futuro da profissão de Treinador depende do conhecimento da sua realidade atual. A Confederação de Treinadores de Portugal, em parceria com o Instituto Português do Desporto e Juventude (IPDJ), está a desenvolver o Estudo de Caracterização do Treinador – Projeto de Investigação "O Treinador em Portugal". Este estudo nacional visa conhecer melhor quem são os treinadores com Título Profissional de Treinador de Desporto (TPTD) em Portugal, como exercem ou exerceram a sua atividade e quais os desafios que enfrentam ou enfrentaram, contribuindo para a definição de futuras políticas, medidas e estratégias que reforcem o reconhecimento, a valorização e o desenvolvimento da profissão. Uma das ferramentas deste estudo é este questionário que demora cerca de 8 minutos a preencher e que pedimos a vossa melhor colaboração uma vez que é uma oportunidade para dar voz aos treinadores e ajudar a construir o futuro da profissão do Treinador em Portugal.

Referência/Grat nº: NA
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2. Aquatic Literacy for All Children (ALFAC project)

The ALFAC project is a partnership between researchers, educators and institutional stakeholders from Europe aiming to improve the quality of aquatic education. It addresses the educational challenge of improving aquatic literacy (AL) levels of children aged 6-12, to better protect them from the dangers of being active in water environments, and to motivate them to engage in water-based activities both now and later. The ten full partners come from seven countries with different drowning accident rates and are involved in water education. In each country, a network of associated partners has been formed to be as close as possible to the pedagogical and structural issues. All partners are representative of the different types of organization and curriculum that can be found in Europe in the teaching of “can swim”. This diversity will allow the results of the ALFAC project to subsequently benefit worldwide. The ALFAC consortium aims to create diagnostic and pedagogical tools to raise the AL level of children. The first step will be to build an international database to compare children's AL levels by age, gender and country. The data collection will take place in partner primary schools in each country and will involve a total of 2500 pupils. The benchmarks through AL dimensions will enable stakeholders to identify the strengths and weaknesses of their organisation and shape pedagogical or structural reforms. The second step will be to produce pedagogical resources that will enable all practitioners, to quickly identify the most important points to address, and the teaching aids to improve them. This phase will be associated with their wide dissemination to the teaching staff of institutions to assess the impact on pedagogical practices. By exploiting our international partnership, by sharing correct implementation of different pedagogical approaches and by making diagnostic and pedagogical tools accessible to all, we aim to develop Aquatic Literacy For All Children.

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