Talent identification in swimming: a viewpoint for freestyle based on performance tracking and deterministic model?

Jorge Morais

Instituto Politécnico de Bragança, Bragança, Portugal
Research Centre for Active Living and Wellbeing (LiveWell), Instituto Politécnico de Bragança, Bragança, Portugal
morais.jorgestrela@ipb.pt

The This viewpoint about talent identification in swimming aims to give information about new insights related to performance and biomechanical determinants in front-crawl/freestyle. This encompasses information related to performance tracking, and identification and monitoring of biomechanical factors, based on deterministic models, that have a meaningful effect into swimming performance. The age of 17 to 18 years seems to be the turning point from where swimmers start to diminish their magnitude of performance improvement. Thus, coaches and practitioners are advised to maintain the training identification programs until such ages. Based on deterministic models, it is possible to understand the interaction between determinants related to stroke mechanics that have a meaningful effect into swimming performance of front-crawl/freestyle.

Key words: talent determinants, monitoring, success pathway

Talent identification (TI) programs in sports are structured systems designed to identify sportsmen with great athletic potential at early ages. These programs are commonly employed by sports organizations, clubs, academies, and national governing bodies to discover and nurture talented athletes who demonstrate the aptitude and attributes necessary for success in their respective sports (Vaeyens et al., 2009). Overall, the primary goals of talent identification programs include: (i) identification – identifying athletes with the potential to reach the highest performance in adulthood and the main traits related to it; (ii) development – understand the changes in the performance and determinant factors according to training program, and; (iii) and follow-up – learn about the changes in the performance and determinant factors during a time frame (Johnston et al., 2018). Nonetheless, these can also include: (i) talent pathway – creating structured pathways for talented athletes to progress through various levels of competition, from basis to elite levels, and; (ii) talent transition – assisting athletes in transitioning from youth to senior levels of competition and providing support for their educational and career development (Cury et et., 2024). Being a multifactorial sport, swimming performance is strongly dependent from the interactions between several scientific factors from different fields of science (Barbosa et al., 2010). Through deterministic models it is possible to have deeper insights about such interactions. This is a modeling paradigm that determines the relationships between a movement outcome measure and the main determinants that produce such a measure (Chow, Knudson, 2011). Based on such deterministic models it is possible to understand that several pathways can be used to improve performance (Barbosa et al., 2013).

Simultaneously with identifying swimming performance determinants, researchers and coaches should also track their swimmers since early ages. Competition performance during childhood and until adulthood can be a misleading measure when trying to predict future world-class swimmers (Born et al., 2023). During childhood, swimmers as any other children undergo processes of maturation and growth (Malina et al., 2021). These processes, which are reflected on the increase of the swimmers' body dimensions, have a strong effect on their stroke mechanics and energetics (Latt et al., 20; Morais et al., 2017). Literature about performance tracking in swimming have indicated that during childhood the rate of improvement is greater and there is a moment in their career where this rate starts decreasing (Costa et al., 2011). It was shown that the 17 – 18 years of age seems to be the turning point from where the magnitude of increase starts diminishing (Born et al., 2023). Therefore, it was suggested that the swimming community should maintain the talent identification process at least until these ages. This will allow to not lose swimmers who do not draw attention to themselves by exceptional results during early junior age (Born et al., 2023).

Most studies about TI in swimming include the measurement of anthropometric variables (Barbosa et al., 2019; Nevill et al., 2020). This occurs because it was shown that anthropometric features play key roles in kinematics, kinetics, hydrodynamics, energetics, efficiency, and swimming performance (Barbosa et al., 2013). Overall, studies have reported that the fastest freestylers have bigger body dimensions than their slowest counterparts (Barbosa et al., 2019; Nevill et al., 2015). This allows swimmers to present: (i) better stroke kinematics, i.e., fastest stroke frequencies and larger stroke lengths; (ii) greater propulsion, i.e., in-water force during the arm-pull; (iii) greater efficiency, i.e., smaller values of intra-cyclic swimming speed, greater stroke index and propulsive efficiency, and; (iv) despite presenting larger frontal surface areas, fastest swimmers tend to present smaller drag coefficient (Morais et al., 2022). Therefore, researchers and coaches should monitor their swimmers' anthropometrics to understand which ones could be more likely to deliver the best performances in older stages.

In the case of front-crawl/freestyle, performance is strongly dependent on the ability of each upper limb to exert propulsion independently. For this reason, it is important to understand the propulsion of each upper limb separately. One study, using pressure sensors placed on each hand, found that the dominant upper limb generated significantly greater propulsion than the non-dominant upper limb (Morais et al., 2020). Therefore, the swimming speed achieved when executing the dominant limb was substantially faster than that of the non-dominant limb. In front-crawl/freestyle, at maximum speeds (tests or official competitions), swimmers may present variability between stroke cycles with a tendency for a decrease in speed throughout the course (Morais et al., 2021). This trend was also observed in propulsion and swimming speed when performing each upper limb (Morais et al., 2020). In other words, a decrease in swimming speed was associated with a simultaneous decrease in propulsion. Therefore, it can be indicated that greater propulsion generates faster swimming speeds.

However, and as aforementioned, performance models based on deterministic models depend from several interactions from different variables (Barbosa et al., 2013). There is not only one path or interaction for the performance improvement. Stroke frequency is a variable usually used by coaches to control swimming pace, as it is quickly quantifiable during training or competition. Furthermore, faster cadences are related to faster speeds

(Koga et al. 2020,19). However, through manipulation of stroke frequency, it has been reported that increasing this can have a negative effect on propulsion, and therefore in swimming speed (Koga et al. 2020). An increase in gesture frequency by 10% beyond that recorded during maximum swimming (i.e., 110 and 120%) was tested. The main results demonstrated that a 10% increase in gesture frequency, in relation to that applied during maximum swimming, allowed swimmers to increase their swimming speed from 1.75 to 1.76 m/s. However, a 20% increase by the stroke frequency led to a decrease in swimming speed (from 1.75 to 1.74 m/s) (Koga et al. 2020). The authors found that the angle of attack during the upward phase and the average propulsion of the hand were lower when the stroke frequency was performed at 120% compared to 100%. Interestingly, swimming speed was similar between 100 and 120%, despite the decrease in propulsion. This phenomenon may be related to the increase by the stroke frequency. In front-crawl/freestyle, increasing stroke frequency causes an increase in the overlap of propulsive phases (Chollet et al., 2000). In other words, there is a temporal decrease between the propulsion of one limb and the other, which may have compensated for the decrease in propulsion.

Biomechanically, swimming speed depends on the product between the stroke frequency and the stroke length (Craig, Pendergast, 1979). Therefore, swimmers can maximize their swimming speed by increasing stroke frequency, stroke length, or both. In the specific case of sprinters, it has been demonstrated that elite swimmers present an all-out strategy (Morais et al., 2021). That is, sprinters exhibit a decrease in swimming speed over time, with a decrease by the stroke frequency and an increase in stroke length over time. However, it has been suggested that swimmers may need to change the stroke frequency–stroke length distance combination to maintain a given pace (Dekerle et al, 2005). Additionally, whenever swimmers are unable to maintain stroke rate, they are often advised to maintain cycle distance to minimize the decrease in swimming speed (Termin, Pendergast, 2000). However, there is little information about the effect that propulsion may have on this stroke frequency–stroke length interaction. For this reason, Morais and co-workers aimed to understand these combinations associated with swimming speed and propulsion in sprinters of both sexes (Morais et al., 2022). The authors found that the fastest swimming speed, in both sexes, was not achieved with the fastest stroke frequency nor the longest stroke length.

Furthermore, greater propulsion values were not responsible for promoting the fastest swimming speeds. The fastest swimming speed was achieved at an “ideal” stroke frequency–stroke length combination. As previously reported, in sprint events, there is a tendency for a decrease in stroke frequency throughout the race and a consequent increase in the stroke length. However, it was indicated that this relationship is not always inverse (Morais et al., 2022). Instead of a clear inverse relationship, a sinusoidal profile was observed between stroke frequency and stroke length. That is, several stroke frequency–stroke length combinations can be observed. Furthermore, the fastest swimming speed was not achieved by greater propulsion when interacted with stroke frequency and stroke length (Morais et al., 2022). In swimming, the propulsion produced by the swimmer is not always in the direction of displacement of the body's center of mass (Soh, Sanders, 2019). Therefore, an increase in the magnitude of propulsion may not produce a direct and significant increase in swimming speed. As previously reported, exceeding the stroke frequency of maximum speed has been shown to reduce hand propulsion during the upward phase, caused by decreased angle of attack (Koga et al. 2020). If sprinters are instructed to perform very fast cadences, this can result in rushing hand input and producing less force or a misguided vector force. Furthermore, faster cadences are obtained by increasing hand speed, which can promote greater propulsion. However, if the swimmer does not have sufficient strength or stability, the movement pattern may change to encounter less resistance in the hand and, consequently, reduce propulsion. Thus, the effective propulsion (force in the direction of travel) is reduced. Exerting a greater amount of propulsion may not be mechanically advantageous if it is not well guided by the hand. This rationale was basically showed in a recent study that used path-flow analysis (Morais et al., 2024). It was noted that propulsion generated by the upper limbs had a positive and significant effect into stroke frequency but not into stroke length. The authors argued that in the case of maximal trials (such as sprint events) it seems that when swimmers reach a given maximum stroke frequency, by generating greater propulsion, they are not able to increase their stroke length at the same time (Morais et al., 2024). On the other hand, it was noted that the drag coefficient (that gives an overall insight about the swimmers' hydrodynamic profile) did had a significant contribute to the stroke length. Specifically, a smaller drag coefficient contributed to larger stroke lengths (Morais et al., 2024). This highlights the multifactorial phenomenon that swimming performance is, where the interaction between several determinants plays a key role.This viewpoint about talent identification in front-crawl/freestyle underlines two major aspects for coaches and practitioners: (i) performance tracking, and; (ii) interaction between performance determinants more related to stroke mechanics. They must be aware that the 17 – 18 years of age seems to be threshold from where swimmers start to dimmish their magnitude of performance increase. Thus, they are advised to maintain the talent identification process until these ages. The performance of front-crawl/freestyle, specifically in sprinters, seems to be determined by the interaction of several determinants related to stroke mechanics. Coaches and practitioners must be aware that promoting increases or improvements in all determinants at the same time may not be the most adequate manner to excel performance. They are advised to monitor their swimmers' stroke mechanics and understand the individual/intrinsic characteristics of each swimmer as a unique individual.

References

Barbosa T., Costa M., Marinho D. Proposal of a deterministic model to explain swimming performance. Int J Swim Kinet, 2013, 2(1), 1–54.

Barbosa T.M., Bartolomeu R., Morais J.E., Costa M.J. Skillful swimming in age-groups is determined by anthropometrics, biomechanics and energetics. Front Physiol, 2019, 10:73.

Barbosa T.M., Bragada J.A., Reis V.M., Marinho D.A., Carvalho C., Silva A.J. Energetics and biomechanics as determining factors of swimming performance: updating the state of the art. J Sci Med Sport, 2010, 13(2), 262–9.

Born D.P., Bjorklund G., Lorentzen J., Stoggl T., Romann M. Specialize early and select late: Performance trajectories of world-class finalists and international- and national-class swimmers. Int J Sports Physiol Perform. 2023, 19(2), 164–172.

Chollet D., Chalies S., Chatard J. A new index of coordination for the crawl: description and usefulness. Int J Sports Med, 2000, 21(01), 54–9.

Chow J.W., Knudson D.V. Use of deterministic models in sports and exercise biomechanics research. Sports Biomech. 2011, 10(3), 219–33.

Costa M.J., Marinho D.A., Bragada J.A., Silva A.J., Barbosa T.M. Stability of elite freestyle performance from childhood to adulthood. J Sports Sci, 2011, 29(11), 1183–9.

Craig A.B., Pendergast D.R. Relationships of stroke rate, distance per stroke, and velocity in competitive swimming. Med Sci Sports, 1979, 11(3), 278–83.

Cury R., Sotiriadou P., Kennelly M. Talent transfer: A complementary elite sport development pathway. Manag Sport Lei, 2024, 29(2), 310–23.

Dekerle J., Nesi X., Lefevre T., Depretz S., Sidney M., Marchand F., et al. Stroking parameters in front crawl swimming and maximal lactate steady state speed. Int J Sports Med, 2005, 26, 53–58.
Johnston K., Wattie N., Schorer J., Baker J. Talent identification in sport: a systematic review. Sports Med, 2018, 48, 97–109.
Koga D., Gonjo T., Kawai E., Tsunokawa T., Sakai S., Sengoku Y., et al. Effects of exceeding stroke frequency of maximal effort on hand kinematics and hand propulsive force in front crawl. Sports Biomechanics, 2020, 23(1), 15–27.
Latt E., Jurimae J., Haljaste K., Cicchella A., Purge P., Jurimae T. Longitudinal development of physical and performance parameters during biological maturation of young male swimmers. Percept Mot Skills, 2009, 108(1), 297–307.
Malina R.M., Kozieł S.M., Králik M., Chrzanowska M., Suder A. Prediction of maturity offset and age at peak height velocity in a longitudinal series of boys and girls. Am J Hum Biol, 2021, 33(6), 23551.
Morais J.E., Barbosa T.M., Gomeñuka N.A., Marinho D.A. Effects of anthropometrics, thrust, and drag on stroke kinematics and 100 m performance of young swimmers using path-analysis modeling. Scand J Med Sci Sports, 2024, 34(2), e14578.
Morais J.E., Barbosa T.M., Lopes T., Simbana-Escobar D., Marinho D.A. Race analysis of the men's 50 m events at the 2021 LEN European Championships. Sports Biomech, 2022, [Epub ahead of print].
Morais J.E., Barbosa T.M., Neiva H.P., Marques M.C., Marinho D.A. Young swimmers' classification based on performance and biomechanical determinants: Determining similarities through cluster analysis. Motor Control, 2022, 26(3), 396–411.
Morais J.E., Barbosa T.M., Nevill A.M., Cobley S., Marinho D.A. Understanding the role of propulsion in the prediction of front-crawl swimming velocity and in the relationship between stroke frequency and stroke length. Front in Physiol, 2022, 13: 876838.
Morais J.E., Forte P., Nevill A.M., Barbosa T.M., Marinho D.A. Upper-limb kinematics and kinetics imbalances in the determinants of front-crawl swimming at maximal speed in young international level swimmers. Sci Rep, 2020, 10(1), 11683.
Morais J.E., Silva A.J., Marinho D.A., Lopes V.P., Barbosa T.M. Determinant factors of long-term performance development in young swimmers. Int J Sports Physiol Perform, 2017, 12(2), 198–205.
Nevill A.M., Negra Y., Myers T.D., Sammoud S., Chaabene H. Key somatic variables associated with, and differences between the 4 swimming strokes. J Sports Sci, 2020, 38(7), 787–94.
Nevill A.M., Oxford S.W., Duncan M.J. Optimal body size and limb length ratios associated with 100-m personal-best swim speeds. Med Sci Sports Exerc, 2015, 47(8), 1714–1718.
Soh J., Sanders R. The clues are in the flow: how swim propulsion should be interpreted. Sports Biomech, 2019, 20(7), 798–814.
Termin B., Pendergast D. Training using the stroke frequency – velocity relationship to combine biomechanical & metabolic paradigms. J Swim Res, 2000, 14, 9–17.