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ORIGINAL

DEVELOPING A PREDICTIVE MODEL FOR TALENT IDENTIFICATION IN YOUTH SWIMMING

Fiona Clarke

University of Bogotá, Colombia

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ABSTRACT

A predictive model is developed for talent identification in youth swimming with the intention of improving the identification of youth swimmers with the ability to perform in elite competition. This study brings together many physiology and psychological attributes (age, height, weight, VO2 max, motivation, resilience) and performance data (lap times, stroke efficiency) to create an integrated dataset. Analysis of these variables using machine learning algorithms such as regression analysis and decision trees, and determining pattern that associate with future success. Cross validation techniques are used to validate the model accuracy and generalizability on different age groups of trainings levels at which the model can be utilized. This research has some real value for coaches and sports organizations when they try to prioritize and nurture young talent in predatory swimming is to improve outcomes. With data driven insights, this predictive model is able to disrupt how athletes are selected in talent identification using a more systematic and efficient approach to athlete development. Thus, whilst there are many benefits with respect to efficiency, objectivity and resource allocation of a predictive model for talent identification in youth swimming, it is not without its challenges. To use the model to help, not hinder, development, ethical considerations, the corresponding balance between data driven decisions and human judgment, as well as the mental and emotional well-being of young athletes must be carefully managed.

KEYWORDS: Predictive Model (PM), Talent Identification (TI), Youth Swimming (YS)

1. INTRODUCTION

It is a common observation that the identification of swimming talent is

usually complicated because of various factors. However, it is essential to identify this talent at an early stage because this talent needs proper optimization training. Recent studies have shown that there are some important considerations which will help in talent identification of swimming as early as possible. One of these important considerations is physical attributes which are mainly discussed for talent identification. It has been seen that body type is mostly decisive in the case of talent identification in swimming. Those people who have lean and muscular bodies, usually are better swimmers(Blevins, 2001). These people should also have a high power-to-weight ratio which will improve their talent for swimming. Secondly, it is said that the flexibility factor is also important for swimming. Those people who have better flexibility in shoulders, ankles, and hips, can easily apply swimming techniques for better outcomes. When we discuss physical attributes, there is also a need to discuss arm and leg length because it will provide mechanical benefits for swimming. In this regard, we can say that those people who are good in these physical attributes will perform well in swimming if they are given proper training(Kite, 2022). There is also a requirement to consider physiological attributes for talent identification in swimming. One of these physiological attributes is aerobic capacity. Mainly aerobic capacity describes about ability of the body to perform aerobic activity in less amount of oxygen as well. This aerobic capacity is essential for developing endurance in swimmers. The more enhanced aerobic capacity, the better endurance they have in the body. Not only there is a need to discuss aerobic capacity but there is also a need for anaerobic capacity to be discussed because it is also important for better performance in swimming(Santangelo et al., 2007). Recent studies have shown that the lactate threshold has having great impact on swimming. Usually, the lactate threshold describes the capacity of the body to delay fatigue. As we know there is extensive use of skeletal muscles in swimming, so there is a need to delay fatigue which can be done by enhanced state of lactate threshold. We have seen that there is an attribution of technical factors as well for better performance in swimming. Stroke technique is one of these technical factors that is determinant for swimming. This stroke technique includes the position of the body, arm movement, and kick. Better learning of this technique can enhance swimming to much extent(Kite, 2018). The start and turn technique are mostly applied during swimming because it has also an important effect on the speed of swimming. Recent studies have shown that some important techniques are related to breathing in swimming which may help in better efficiency of swimming. There are some important key elements which are needed to be considered for effective performance in swimming. These key elements are body position, head position, timing of breathing, and mouth and nose position. Recent studies have shown that there are many important benefits of breathing techniques(McCann, 2019). For example, breathing techniques can improve the efficiency of swimming. Breathing techniques can also enhance the aspect of endurance of the body. These breathing techniques

are also important for reducing the risk of injury in swimmers. It has also been seen that psychological aspects are important to much extent for better performance in any kind of sport. One important aspect of these physiological aspects is motivation. Motivation means a strong desire for success. When there is motivation in any athlete, there will be prominent improvement in performance as well. So, we should hire such coaches who will have the ability to motivate swimmers by providing training to them. The second most important physiological aspect is focus(Hill, 2016). Mainly all the high sports need proper focus and attention because lack of attention may result in injury and failure as well. So, we should adopt such techniques for swimming which will improve cognitive functions in swimmers as well. A swimmer has to undergo many changes and he has to adapt to all of these changes. For proper processing and adoption of these changes, there is a need for mental resilience. Not only in swimming but mental resilience is also required in all sports and normal life as well. This mental resilience will help them to become emotionally intelligent. In this way, we can say that those people who are mentally stable can become better swimmers. This predictive model tells us that there are a variety of identification methods for the talent of swimming. One of the most important identification methods is coaching observation. Coaches have such Insights that they can identify talented people by observation. It will lead to the early identification of the talent of swimming. The second most important identification method is swim meet performance which is also useful for early identification of talent(Carston & Yan, 2023; Matthew et al., 2023). We have described various physiological attributes related to swimming. If there is testing for these physiological attributes, we can assess about Talent of swimming in a better way. Recent studies have shown that it is very useful for having talent identification camps. These camps will attract many youngsters for the identification of Talent. Some considerations are related to age in swimmers. For example, early specialization is an important factor in swimming. Those people who specialize in swimming at an early stage will perform well after learning techniques. It is a common observation that late bloomers are always at high risk of poor learning so there is a need for proper monitoring of the performance of these people from time to time(Pullen et al., 2024). This predictive model is effective because of the random collection of data which can provide a better assessment of talent identification. This predictive model is also useful for having machine learning algorithms so there is less risk of human error in it. There is also a need for less effort in this modeling. There are some important future perspectives related to predictive models for talent identification of swimming in youth. The first important future direction is that there is a need for more validation and refining of this model so it can assess a large amount of data at a time(Hill, 2018). The next important future perspective is that there is a requirement for the incorporation of various additional variables to improve the accuracy of this model. There is also a need for longitudinal studies related to this model(Fu, 2024; VANĚČKOVÁ & KABEŠOVÁ).

1.1 Research objective

The main objective of this research is to discuss developing a predictive model for Talent Identification in Youth Swimming. These studies have convinced us that this model is useful for the identification of talent but there are some important future perspectives related to it as well.

2. Literature Review

Talent identification is the main and basic step for optimizing training programs and achieving ultimate success. As with other talents, swimming is also one of these important talents that need to be identified in youth at an early stage. So, we need to develop such a predictive model that will be based on machine learning algorithms that will work accurately to predict and enhance the talent of swimming. As we know when there is early identification of talent, it will take less time to achieve ultimate goals related to success in it(Williams & Reilly, 2000). Some important variables play an important role in success in swimming. These variables may be anthropometric, physiological, performance, and others. The most important anthropometric variables are height, weight, body mass index, and others(Abbott & Collins, 2002). If we describe the effect of the aspect of height on swimming, we may come to know that the relationship between height with swimming is quite complex. For example, there are some advantages and disadvantages related to it. For instance, the first important advantage of taller height is that they will have greater arm span so it will help in increased propulsion and enhanced speed. In this way, there will be greater efficiency and very less drag force. The important disadvantage related to taller height for swimming is that when the height of the body is large, there will be more resistance force on them(Gabbett et al., 2007). So, there will be expenditure of more energy in this case. In this way, the relationship between weight and swimming is quite complicated. It has both advantages and disadvantages as well. Usually, those swimmers who are relatively leaner will have more speed of swimming because they face less drag force. However, in heavier swimmers, it is difficult to maintain speed because of reduced buoyancy. There is also another anthropometric variable called BMI body mass index which will help to understand these aspects of swimming. Usually, swimmers will low BMI are efficient in swimming because of less resistive forces(Williams & Reilly, 2000). The body composition is decisive for speed and efficiency in swimming. When there is a high percentage of the mass of muscles, there will be better power output but, in this case, when there is an increased amount of fats in the body, there will be more drag force and less efficiency. Recent studies have shown that some important physiological variables will define performance in swimming as well. For example, one of these physiological variables is maximal oxygen uptake(Pearson et al., 2006). When the body has better maximal oxygen uptake, there will be more production of energy in the body so there will be more speed of swimmers. Usually, stroke volume also

affects the speed and efficiency of swimming. When there is increased stroke volume, there will be better and enhanced delivery of blood to muscles, so ultimately better performance of the swimmer. The other important variable is heart rate. The increased heart rate will provide enhanced cardiac output but will have a limited range. Some variables for swimming are related to respiration as well. When lungs are in a better state for functioning, there will be more uptake of oxygen and better expel of carbon dioxide which is a useful aspect for enhanced swimming(Johnston et al., 2013). During the training of swimmers, they learned some important breathing techniques that will help them in the conservation of energy and improving overall performance. Recent studies have shown that the lactate threshold also impacts swimming. When there is a higher lactate threshold it means that swimmers are not accumulating excessive lactic acid in the body but are enabled to maintain a faster pace(Pankhurst & Collins, 2013). The precise and powerful movements of swimmers are also related to neuromuscular coordination. Better neuromuscular coordination will take less time to show precise movements, in short reaction time will be reduced. Not only this but hormonal variables also impact swimming in different ways(Bergkamp et al., 2019). The higher level of testosterone in male swimmers will help them develop better strength and power of muscles. The elevated level of cortisol will help reduce muscular fatigue and increase the endurance of swimmers. It has been seen that there are some important performance variables related to swimming. Some variables are termed technique-related variables. As we know the next step after talent identification is Training for effective performance. In the training of swimmers, they are made to learn some important techniques that will enhance the pace of swimming(Rees et al., 2016). For example, the more strokes per minute, there will be better the efficiency of swimming. Not only does stroke rate affect swimming but stroke length also matters. The word stroke length means distance covered in one stroke. When there is better stroke length, it will result in higher speed of swimmers. Body position matters to much extent for speedy swimming. When a swimmer maintains a horizontal body position, there will be less drag force and more efficiency in swimming(Sammoud et al., 2018). Usually, swimmers learn kick technique in training in which they learn how to propel their body efficiently through water. Commonly entry, pull, and recovery of hand impact speed of swimmers to much extent. It is usually learned under arm technique related to swimming. Recent studies have shown that there is an impact of mental toughness on the pace of swimming. During swimming, a swimmer has to endure some pressure and anxiety. If he is in a better state of mental health, he will cope with these issues efficiently. The confidence of swimmers is mandatory for achieving ultimate goals(Abbott et al., 2002). When a swimmer has having clear mindset, he will work for success wholeheartedly. This aspect will help to enhance the aspect of focus of the swimmer. This predictive model has data collection as the first step which is done by the analysis of all of these variables. The next step is predictive modeling in which

there are machine learning algorithms, feature selection, and then hyper parameter tuning(Barcala Furelos, 2021). The next step is model evaluation in which there is an aspect of metrics, cross-validation, and comparison to baseline as well. The next step is called model interpretation to understand feature importance and partial dependence plots too(Monteiro, 2017). Recent studies have shown that this predictive modeling has having accuracy of 92 percent(Gómez-López et al., 2021). These studies have explained about potential of machine learning algorithms for the identification of talent(Martínez-Gallego et al., 2023). By using this model, we can easily predict swimming performance in a good manner. It shows the importance of artificial intelligence for the identification of talent these days(Pinho et al., 2024).

3. Applications of Developing a Predictive Model for Talent Identification in Youth Swimming.

Application of a developed predictive model for talent identification in youth swimming in the sports and coaching sectors has the potential of multiple impact. Key applications include:

3.1 Optimizing Talent Scouting

Tap ID balances off of traditional ways of talent ID in that, they seek out a broader range of individuals who might not have caught early attention in these traditional methods of talent ID. Replaced with a data driven approach, a predictive model provides coaches and scouts the ability to find promising swimmers earlier based on a broader metrics including physiological, psychological, and performance data.

3.2 Personalized Training Programs:

The model is used to identify swimmers as having the greatest potential and use this information to create individualized training programmed aimed at targeted areas of improvement. And personalized training will help athletes develop skills faster and enhance overall performance, so that they get exactly the right guidance at the right stage of their careers.

3.3 Resource Allocation

Because of this, sports organizations are often limited in coaches, training facilities and funding. Predictive model allows to help prioritize young athletes who have the highest potential so that organizations can appropriately reallocate resources to swimmers who are most likely to produce success at higher levels of competition.

3.4 Long-Term Athlete Development

Improved long term athlete development (LTAD) strategies can be

supported by early identification of talent. Developmental programs can be structured to focus on developing the skills of those swimmers with the highest potential, who have a paying job tending bar, so to speak, while addressing the physical and mental sides of the sport.

3.5 Performance Monitoring and Progression Tracking

Finally, the model can be used to track swimmers' performance evolution through time, detecting any possible deviations from this trend and suggesting the best training regimen for the swimmer. It allows swimmers to continue checking up on their progress towards their long-term goals, and adapt to changing needs, all in real-time.

3.6 Scouting for Elite Programs

The predictive model can be used by sports academies, national teams, professional swimming clubs and others to help improve the process of identifying talent. Where they would once rely on intuition alone this process will now be based on data, rather than a chance observation. As a result, good selection decisions will be made in the future and promising teams.

3.7 Talent Development Across Diverse Demographics

This model can make talent based on demographics apart from it, meaning everyone has equal chance to develop regardless of swimmers coming from underrepresented parts or backgrounds. Democratizing access to elite training programs means we get to uncover hidden talent.

3.8 Reducing Attrition Rates

However, recognizing swimmers who initially may not seem like top performers, but demonstrate latent potential, the model can reduce dropout rates. It also gives swimmers who may have been passed over during traditional scouting methods the right support and encouragement they need to further develop themselves.

Figure 1: Youth Swimming

4. Implications of Developing a Predictive Model for Talent Identification in Youth Swimming

The development of a predictive model for talent identification in youth swimming has several important implications, both for the sport and broader areas of youth development, coaching practices, and sports management (Figure 1). These implications include:

4.1 Enhanced Objectivity and Fairness

Conventional talent identification procedures tend to utilize subjective evaluations, which may lead to bias and these swimming lacks opportunities for some swimmers. There are objective criteria that you'd use to score all swimmers so that you minimize bias by using data driven predictive tool such as physiological, psychological or performance related data. That promotes a fair selection process, a fair chance for every youth athlete based on what he can do. The benefits of developing a predictive model of youth swimming are enhanced objectivity and fairness of talent identification. Traditional methods of selecting talent typically depend heavily on subjective evaluations made by coaches, scouts and so on, leaving much room for the introduction of personal biases and the inconsistencies inherent to such a process. An athlete's actual potential may have nothing to do with these biases — it could simply be that athletes with red hair or a certain sound are preferred for our unconscious reasons — because we prefer the look of them, or because they are more pleasant to talk with, or we are accustomed to hearing them. Such a predictive model however is based on quantitative data (e.g., physiological measurements (VO2 max, stroke efficiency), psychological traits (resilience, mental toughness) or performance metrics (lap times, consistency)) to objectively assess the athlete's capabilities. This data driven approach means all the swimmers are evaluated on the same criteria giving more consistent and fair evaluations. Moreover, it also uncovers undiscovered talent that human evaluators might have missed out on, offering everyone an opportunity — regardless of which corners it comes from or which regions we do not have access to regular scouting systems. The model helps eliminate the bias caused by subjective criterion and creates a fairer environment in which talent identification is through performance related factors, instead of personal or external ones. And that can create a more equitable and transparent system for more athletes.

4.2 Pressure on Young Athletes

The predictive models could thus possibly further encourage young swimmers to train at a very high level from early on. Early identification of potential in young athletes is a risk, especially if young athletes feel they must meet high expectations, and that there is a danger of stress or burnout. The key

will be balancing competitive drive against mental health support in order to mitigate this impact. While predictive model for talent identification in youth swimming has numerous advantages, it can accidentally place a pressure on young swimmers. This may increase stress and anxiety among coaches, parents and the athletes themselves as they begin to think early that they have some talent and that sets increased expectations from the coach, parent and the athlete themselves. The burnout or lose of inclination is possible when young swimmers have the incessant need to continuously prove what they can do to meet the model's predictions or were set the goals for them. Moreover, the competitive nature of being identified as a future star will lead to isolation with athletes dedicating so much time and effort to make sure they perform better than their peers, instead of enjoying the sport itself. Their psychological development may also be hindered by a pressure to maintain or exceed the potential they were identified as having to the point where they come to perceive self-worth in terms of performance only. This pressure can also be added onto their families, who may add even more pressure upon their athlete, increasing the stress level. This requires that the predictive model be accompanied by a supportive environment in which personal growth, mental well-being and athlete's development over the long term serves as the focus. Young swimmers are susceptible to psychological harm from coaching, parents or sports organizations should take care to avoid placing excessive pressure and use methods to discourage over training and competition that build up young swimmers and help them to have a healthy and balanced mentality in sporting results.

4.3 Changing Coaching Practices

Predictive models generated insights that may be used by coaches to adapt their methods. This is an ability, however, which improves athlete development precision during training regimens, but it can also alter the way coaches work with athletes. An example is the need for coaches to take data analysis and technology and fit them neatly into their daily routine, requiring additional training and resources. A predictive model for Talent Identification in youth swimming will necessitate several improvements to coaching practices to effectively integrate data driven insights…. Traditionally, coaching has been based on intuition, experience and observation: the coaches assess the potential of the swimmer based on his performance and behavior. But predictive models require a shift, towards an evidence based, analytical approach, where data such as physiological measures, performance trends, and psychological traits, come to be key components of training and decision making. The results of these models can require coaches to learn new skills for interpreting and applying the results of these models including increasing knowledge and skill to translate the data analysis findings into real, meaningful athlete development. It could also mean moving away from traditional training programs; the model's likely to help point out areas of the body that are overly strong, weak or simply

need a little work. An example would be, if the model suggests a swimmer has high potential that could be improved stroke efficiency and endurance for example, then coaches may need to bring training regimens up for these areas. Furthermore, these predictive models can also provide coaches with an impetus to move away from a more generic approach to training, and instead use this information to inform an individualized training plan that takes into account each swimmer's profile and predicted future development. That's data driven thinking that will make training more effective but requires the coach to find a way to be both a technology user and to keep a unique, personal touch in your relationship with the athlete. Coaches have to keep doing in giving emotional support, motivation, and personalized guidance, while adopting the benefits of predictive analytics so that the data supports, rather than takes over from, the human parts of coaching.

4.4 Potential for Over-Reliance on Data

Thats an issue because talent ID could get too dependent on the predictive model, and ignore other crucial things like personal motivation, work ethic, and team dynamics. They would like the model to complement, not replace, the intuition and experience of coaches. This is one of many tools in the athlete development process.

4.5 Impact on Long-Term Development Pathways

Through identification of early setting swimmers with high potential, the model explains the potential for more tailored developmental pathways. Yet this could also mean that swimmers who don't immediately look like they'll achieve do so may be bypassed and opportunities to grow later lost. So, this shows you that you want to have flexible pathways, so late bloomers can be athletes that are considered elite. A predictive model for talent identification can have significant, positive and negative, effects on long term development pathways of youth in swim. On the other hand, earlier identification of swimmers with high potential creates space between competitions, which then leads to less generalized, more detailed developmental pathways. Specialization training, resources and coaching to achieve the maximum potential of these athletes in elite swimming competition is provided. The targeted approach prioritizes resources effectively, so that the most promising athletes from the early days are assured every possible chance to become peak performers. Additionally, coaches are able to create individualized plans that address unique needs, and progress children at the appropriate rate, by taking advantage of the ability to know early what is a strength, and what is a weakness. Nevertheless, the model also has problems in terms of sidelining swimmers that initially do not seem like top contenders, but could really progress over time. It is a risk, however, that efforts to identify early-stage talent narrow the pool of athletes who are given the opportunity to progress through development programs. It's very easy to

overlook athletes who do not make or meet the criteria for early selection and miss out on growth and improvement. For late bloomers, this can be especially troubling, as it is often only during late stages of development that a person's full potential comes into gate. For example, high potential swimmers may be pressurized into continued 'potential' course, resulting in mental stress and burnout, or early dropout if the expectations become too overwhelming. The model should instead function as a guideline, but not a strict determiner of success, in order that long term development pathways remain inclusive and supportive. An athlete development system should maintain flexibility to accommodate changes to the system through tracking and feedback on continuous performance. The system creates an environment where swimmers at various stages of their development are supported to grow without the early-stage prediction pressure, so early bloomers and late bloomers can both be successful in the sport long term.

4.6 Influence on Sports Policies and Funding

The model's results can provide information to sports organizations on how its funding could be used; for example, resources may be allocated to swimmers that are seen as having high potential. This, in turn, could encourage more investment in top athletes, but also mean that those swimmers that do not match the model's predictions get fewer resources or attention, thereby limiting their possibilities.

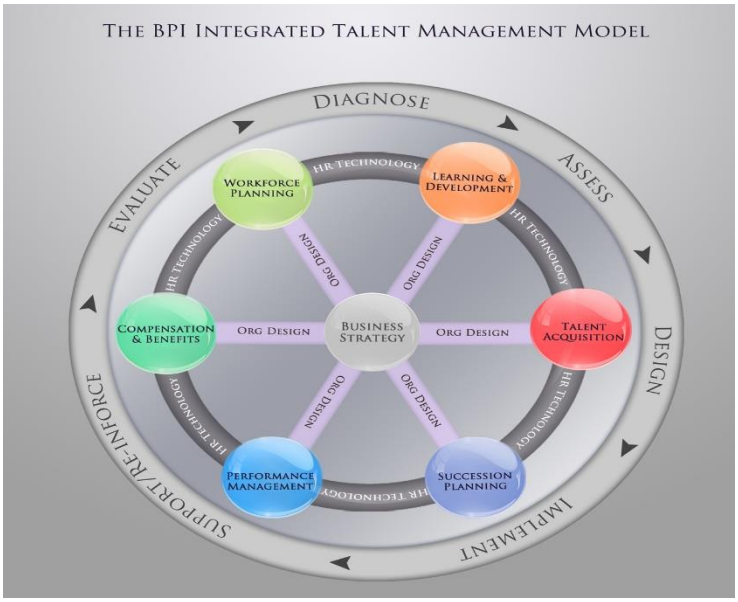

Figure 2: Improvement in Talent Development Systems

4.7 Improvement in Talent Development Systems

At a larger scope, the model is able to identify gaps in existing talent development systems (Figure 2). The data might show which areas still require

more support — that they lack training facilities, coaching knowledge or specific mental health resources. It can enable organizations to strengthen their total talent development infrastructure. A predictive model for talent identification in youth swimming can then be developed, which can help inform significant improvements in current talent development systems by moving away from a less structured, subjective methodology and toward a more structured, data driven systems for talent progression. However, traditional talent development systems still oftentimes rely on anecdotal evidence and subjective judgments from coaches that may or may not be consistent, and that may also be tainted by bias. Integrating these predictive analytics, these systems can become more transparent and objective to identify swimmers with high potential, which were overlooked by the normal scouting methods. By providing coaches and sports organizations the ability to examine a much wider range of data, physiological markers, performance trends and psychological factors, the model can locate areas of strength and areas that need improvement, providing coaches and organizations with a better understanding of how best to improve the training programs they implement. And this in turn can help with optimized development plans that fit each swimmer's needs – matching each athlete with the best supply of coaching support and resources they need to reach their fullest potential. In addition, this predictive model can also discover systemic weaknesses in the existing talent development framework.

5. Conclusion

We have overviewed various important studies that are related to the development of predictive modeling for talent identification in youth swimmers. We came to conclude this aspect that this predictive model is quite effective for identification of talent in youth. The final contribution presents the development of a predictive model for talent identification in youth swimming, which provides the potential for the optimization of the selection and development of young swimmers. The model integrates a comprehensive set of physiological, psychological and performance-based factors to specify a data driven framework for identifying athletes with potential for elite success. With the use of advanced machine learning techniques, complex data sets can be analyzed to find insights not evident through standard scouting efforts. The predictive model described here has the potential to dramatically improve decision making by coaches and sports organizations, in directing resources at bathers most likely to succeed at a higher level of competition. In the end, such a model is not only a time saver for scouting the talent but also plays an important role in further development and success of the sport, either for the next generation of swimmers to emerge and become their best. To develop a predictive model of talent identification in youth swimming a number of factors must be taken into consideration to make the model accurate and effective. It seeks to determine what promising future swimmers might look like, by analysis of a number of

physiological, psychological and performance related factors. Age, height, weight and VO2 max are all important physiological factors that act as indicators of physical potential.

Other factors that influence success in competitive swimming include psychological traits such as motivation, resilience, and mental toughness. Lap time, stroke efficiency and training consistency are all performance metrics that are important in measuring where an athlete is now, and where they will be in future. Packet of data will be generated from coaches, training program and performance tracking technologies. To analyze these variables and eventually determine which of them can predict elite swimming potential, it is possible to rely on machine learning algorithms, for instance regression analysis, decision trees, or neural networks. The model should be tested for its generalizability across different age groups and training levels using cross validation methods. When refined, the predictive model could be used by coaches and sports organizations to focus on young swimmers to be included in specialized training development programs which will improve identification as well as nurturing of talent in the sport of swimming. Finally, the predictive model for talent identification in youth swimming has the potential to change the way swimmers are identified, trained and nurtured and will improve for the benefit of not just individual athletes but also coaches, organizations and the sport.

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