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Original article

The profitability of the turn in freestyle swimmers

La rentabilidad del viraje en nadadoras del estilo libre

A rentabilidade da conversão de nadadores para o estilo livre

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ABSTRACT

The research refers to a study of the profitability of the freestyle turning action in school swimmers. The objective of the research was focused on evaluating the temporal characteristics during the action of the turn in swimmers of the 13 and 14 years old category in the province of Sancti Spíritus. For the collection of information, the empirical level methods used were: scientific observation, as well as measurement. Two video cameras, placed in series, and a Sony underwater camera were used. For the temporal analysis, the Kinovea software, ver 0.9.3, was used. The 15 m *test* was applied to check the profitability of the turn. It was possible to verify a poor effectiveness of this technical element in the freestyle in the swimmers evaluated, which showed, in a generalized way, deficiencies during the impulse phase and the formation of very open angles of the legs that favored a deficit in the use of the power of the legs during the wall push, This aspect helped to decrease the sliding and to begin to perform the exit movements to the surface prematurely, increased the time in general in the execution of the turn, concluding that for the school categories it is appropriate to obtain angles between the ankle, knee and hip joints in the range of 90° and 110° at the moment of initiating the wall push.

Keywords: Turnover; profitability; swimmers; explosive strength; freestyle.

RESUMEN

La investigación se refiere a un estudio de la rentabilidad de la acción del viraje del estilo libre en nadadoras escolares. El objetivo para la investigación se centró en evaluar las características temporales durante la acción del viraje en nadadoras de la categoría 13 y 14 años de la provincia de Sancti Spíritus. Para la recogida de la información, se utilizaron los métodos del nivel empírico: la observación científica, así como la de medición. Se utilizaron dos cámaras de videos, ubicadas en serie, y una cámara subacuática marca Sony. Para el análisis temporal, se requirió del software Kinovea, ver 0.9.3. Se aplicó el *test* de 15 m. para comprobar la rentabilidad del viraje. Se pudo comprobar una pobre efectividad de este elemento técnico en el estilo libre en las nadadoras evaluadas, lo que mostró, de forma generalizada, deficiencias durante la fase de impulso y se comprobó la formación de ángulos muy abiertos de las piernas que favoreció un déficit en la utilización de la potencia de las piernas durante el empuje de la pared, aspecto este que ayudó a disminuir el deslizamiento y comenzar a realizar los movimientos de salida a la superficie de forma prematura, aumentó el tiempo de forma general en la ejecución del viraje, concluyendo que para las categorías escolares es oportuno obtener ángulos entre las articulaciones de tobillos, rodillas y cadera en el rango de los 90° y 110° al momento de iniciar el impulso de la pared.

Palabras clave: Viraje; Rentabilidad; Nadadoras; Fuerza explosiva; Estilo libre.

RESUMO

A pesquisa diz respeito a um estudo sobre a rentabilidade da ação de viragem em estilo livre em nadadores escolares. O objectivo da investigação foi centrado na avaliação das características temporárias durante a ação de viragem em nadadores de 13 e 14 anos de idade na província de Sancti Spíritus. Para a recolha de informação, foram empregues métodos empíricos: observação científica e medição. Foram instaladas duas câmaras de vídeo, colocadas em série, e uma câmara subaquática Sony. Para a análise temporal, foi utilizado o software Kinovea, ver 0.9.3. O teste de 15 m foi executado para verificar a

relação custo-benefício da curva. Foi possível constatar uma baixa eficácia deste elemento técnico no estilo livre dos nadadores avaliados, que mostraram, em geral, deficiências durante a fase de impulso e a formação de ângulos de pernas muito abertos que favoreceram um défice na utilização da força das pernas durante o impulso para a parede, Este aspecto permitiu reduzir o deslizamento e começar a realizar os movimentos de saída para a superfície antecipadamente, aumentou o tempo total na execução da curva, concluindo-se que para as categorias escolares é adequado obter ângulos entre o calcanhar, o joelho e as articulações da anca na gama de 90° e 110° no momento de iniciar o impulso da parede.

Palavras-chave: Rotatividade; Rentabilidade; Nadadores; Força explosiva; Estilo livre.

INTRODUCTION

Swimming as a physical activity performed by man has very significant features that differentiate it from other sports disciplines; it takes place in an environment that is not the usual one for man, the position adopted for the displacement also differs from the usual one, the morphological structure is not designed to swim with total fullness, the forces that act and constantly oppose the swimmer's progress are added to it, the physical conditional capacities of man, the coordinative and cognitive capacities, are added to the long list of factors to be solved in a gradual and planned way through the training process that, according to the Preparation Program of the Swimming Athlete in Cuba, consists of three stages for its development.

The historical background on the emergence and development of swimming makes it clear that the improvement of the styles that are currently regulated has not been an easy conquest, science is the one which has played the predominant role in such progress, in the dynamics of work and experience that are accumulated new and complex tasks to solve appear, this aspect that involves coaches, athletes and specialists from other sciences, in the search for solutions to achieve the optimal direction of the training process.

The swimming strokes have several elements that are integrated and make up the competitive exercise as a whole, which combine acyclic and cyclic movements, although the latter is the most prevalent movement during the performance of the competitive activity. There has been a gradual interest in the execution of acyclic movements, represented by the action of the start and turns, studies by Maglischo (1982) show that 25 and 30 % correspond to these movements.

Of the acyclic movements, undoubtedly, the turn has a greater impact on the sporting result, (Born, Kuger, Polach and Romann, 2021) data collected over several years conclude that, on average, perfected starts can reduce the time spent by 0.1 tenth of a second and efficient turns by 0.2 seconds, (Maglischo, 1982a), depending on the distance and modality of the competitive activity. Arellano (2010) argues that a swimmer who manages to improve only 0.33 seconds in each turn, will improve 1 second in a 100-meter race in short pool and approximately 15 seconds in 1500 meters.

At present, in elite competitions, parity is observed in the performance of athletes during the different events; the events are decided by small fractions of seconds, hence the displacements obtained during the impulse of the wall in the execution of the turn**,** is decisive in many occasions to win the event or to impose a new mark. Regarding this, Maglischo (1982b) warns: "The importance of these improvements is seen in the fact

that only 0.44 separated the first swimmer from the fourth in the 50 m. freestyle race at the Atlanta Olympic Games 1996". Then it becomes very necessary to pay more attention and perfect the turns from the technical and physical point of view, in function of the improvement of the sport result in any of the competitive swimming events.

For the effective achievement of the turn, there are two determining factors: the technical execution and the power of the legs; the latter defines, to a large extent, the efficiency of the thrust on the wall to perform an optimal displacement and minimize possible delays that are detrimental to the sport result, while guaranteeing, to a large extent, the quality of the technical gesture, (Lewin, 1985), referring to the turns, expressed:"...the action of the turn demands high levels of reactive strength of the legs to achieve the necessary impulse from the wall and thus the efficient achievement of the technical gesture".

The deficit of specific leg strength in water sports is not exclusive to swimming; in recent studies, published by the journal Podium regarding a diagnosis of special strength in water to athletes of water polo, they conclude that, "in general, it is found that 80% of athletes have deficiencies in the work of special strength in water". (Ramos, Miló, González, 2020) highlight the poor dosage of these exercises in training, as well as the lack of updating of new strength exercises to improve sports performance.

Studies concerning the preparation of swimmers make it clear that the improvement of leg strength and power is a determining factor to optimize the performance of swimmers (Becerra, 2014; Ramirez, 2015), projecting its benefit mainly to the action of the start and to generate propulsion during the swim. They do not allude to the turning action, but, undoubtedly, the performance of these conditional capacities is also needed for the harmonious and profitable achievement of the turn.

More comprehensive studies such as those of Nugent, Comynsy, Warrington (2018), propose strength and conditioning programs in swimmers, with the aim of improving lower body strength and power to optimize the performance of the start and turns. Valentín *et al.,* (2016) propose exercises for the improvement of the turn in swimmers of 9-10 years old from Granma province, like the other authors, they do not leave clearly their dosages, the means to be used, at what stage of the preparation to apply them, when to start and conclude their application.

Undoubtedly, during the last few years there has been an increased interest in scientific studies on the behavior of swimmers during the turn, with a marked emphasis on the contact time of the feet on the wall, the impulse generated by the application of leg power and the glide underwater, showing that these are the fundamental variables that define the profitability of the turning action. Studies such as Takeda *et al.,* (2020) and Blazevich (2021) ensure the usefulness of underwater analysis in the technical phases of the start and turn, which allows obtaining kinematic information on the factors that affect the initial forward speed and deceleration during underwater sliding. Gonjo and Olstad (2020) and (Trinidad, Veiga, Navarro, and Lorenzo, 2020) established relationships between the selected underwater kinematics and the performances in the starts and turns, focusing their efforts in knowing the average speed and distance reached during the underwater glide after the impulse in the start and turn, obtaining correlations of -0.70 with the time in the 15 m. and -0.95 with the 25 m. concluding that it is a relevant factor for the achievement of a good profitability of the phases under study. Chainok *et al.,* (2021) explain that it is of vital importance to achieve a properly executed aerodynamic posture during the underwater glide and the depth reached as a

way for the exit to the surface in an optimal way, managing to minimize the effects of dragging.

Nicol *et al.,* (2019) concluded that the exit distance to the surface after the impulse is a good indicator to improve profitability during the turn. As the underwater distance increases, the turning time tends to be shorter; in view of this, it is recommended that international level swimmers should try to use the underwater phase as far as the Fina rules allow. Rejman and Borowska (2008), in a study to establish the determining criteria for the improvement of turning, conclude that the optimization of thrust and sliding time are subordinated to the maximum use of the potential generated by extending the legs, with simultaneous minimization of the active resistance.

For their part, Sánchez, *et al.,* (2016) propose that it is from the impulse where the main reasons for concern are found, insofar as it influences the evolution of the fluid during sliding and in the subsequent propulsive actions, without forgetting that the final velocity of the impulse depends on the strengthapplied during the impulse. In this regard, Weimar *et al.* (2019) studied the influences of two different thrusts of the legs against the wall on land and in water; the first consisted of a thrust without countermovement, characterized by the rapid extension of knees and hips towards the wall and the second thrust, with countermovement, where the swimmer flexes the knees at an angle of 90°, finding that the greatest amount of strength applied was manifested in the thrust with countermovement on land, where the values of strengths applied within the water are much lower.

This result could be influenced by the laws of physics that are evident when a body is introduced into the water; each movement will be limited by the action of the water resistance, as well as the loss of weight experienced by the body, explained by Archimedes' principle, which suggests that the applications of the strenths differ. Orna *et al.,* (2011) in similar study conclude that they obtained significant reductions in impact strengths by (33 %-54 %), impulse (19 %-54 %) and the amount of strength developed by (33 %-62 %) in water, compared to their equivalents on land in most of the exercises under study and explain that the level of reduction may be influenced by the jumping and damping technique, the depth of the water, as well as the size and body composition of the participant.

Other studies concerning the turning action focus their attention on the effective angle of the legs during the turn and the wall contact time as a premise of the optimal utilization of the leg thrust, (Costa de Oliveira *et al.,*2014; Skyriene *et al.,* 2017). Coming to the conclusion that, the greater the angle formed by the legs during the contact with the wall, the time of the thrust phase is shortened; on the other hand, the athletes who got closer to the wall had to decrease the angle of the legs, increasing the time of contact with the wall, an aspect that is detrimental to the total time of the execution of the turn.

In this sense, it is where the athlete during the turn encounters the first problem to solve, the perception of the right moment to start the turn; from this, it depends on establishing an adequate angle to perform an optimal thrust. Staying with the legs too bent or too extended can negatively influence the profitability of the turn (Skyriene *et al.,* 2017a).

Bearing in mind that the indicators established for the evaluation of turning have a certain degree of complexity, the little relevance that has generally been given to it during the preparation and taking into consideration the criteria of the referenced authors, it is necessary to apply studies and proposals for new pedagogical solutions,

aimed at reducing the exposed problem if it is taken into account that the increase in the number of highly qualified athletes depends, to a great extent, on the correct solution of the issues of physical and technical development from the base.

Currently, the 15 m. *test* is used for the analysis of the return of the lap, proposed by Absaliamov and Timakovoi (1990), used in elite events, such as the world championships of Rome 1994 and Barcelona 2003, as well as in the Olympic Games of Atlanta 96. The previous postulate is used as a reference in the development of this work.

For the realization of this research, authorized sources on the subject were consulted, both nationally and internationally, in order to contribute to the systematization of the object of study. Some of these references have been taken into account for the analysis and comparison of the results shown in later sections. Among these referents are the following: (Arroyo, 2018; Maza, 2017; Reynoso, 2020; Vázquez, 2020).

From the previous analysis, the following objective was formulated to evaluate the temporal characteristics during the turning action in swimmers of the 13 and 14 years old category in the province of Sancti Spíritus.

It has been possible to verify in studies to school groups that practice swimming and in the consulted bibliography, referring to the specific preparation of turns, that these involve a group of determining variables, not very negligible to explore them. Advanced technologies are needed, with the disposition of multidisciplinary groups that propitiate the adequate knowledge, which allow solving the detected deficiencies and thus direct the preparation of the athletes on objective criteria, derived from the evaluation of the temporary variables, together with the methods and procedures used, which are within the reach of the base and high performance trainers who do not have access to highly expensive equipment such as tensometric platforms and high speed recording cameras.

MATERIALS AND METHODS

To carry out the research, the 13-14 year-old female swimming team of the Sport Initiation School (Eide in Spanish) of Sancti Spíritus was selected, composed of four swimmers with an average height of 162 cm. and an average weight of 58 kg.

For the collection of information, the empirical level methods were used: scientific observation, using the video graphic technique, as well as measurement. For data processing, the statistical processor SPSS ver 15.00 was used.

The 15 m. *test* was used for the analysis of the profitability of the lap, which is used in elite swimming events. In addition, a total of 100 meters were swum in the freestyle, the total time performed and the time in the 7.5 meters before the wall and 7.5 meters after the wall were recorded, always having as reference the swimmer's head.

For the temporal analysis, two video cameras were used, placed in series to obtain a complete sequence of the run for later analysis, an underwater camera was also placed to obtain the result of the turning time and the contact time of the feet on the wall, as well as the velocity and linear acceleration during the wall impulse phase.

Speed averages were obtained for the 100 m and 15 m distances. To determine the average swimming speed of the test and of the turn section, the formula Speed= Space/ Time was used.

The strength applied on the wall during the impulse was determined by the indirect method, applying Newton's 2nd law, can be represented by the following equation (Equation 1).

$$F_{neta} = m * a, \quad (1)$$

Where:
Fneta is the total force acting on the object,
m is the mass of the object and *a* is its acceleration. The unit of measurement is represented in Newtons.
To determine the impulse and number of movements, the formula (Equation 2) was used.

$$I=m*v \quad (2)$$

Where:
m is the mass in kg, v is the velocity expressed in m/s.
The values of the mean, standard deviation, as well as the Pearson correlation between the indicators evaluated and the final *test result* were determined.

During the application of the 15 m., *test*, the following indicators were analyzed:

- Approach time (7.5 m. before the wall, until the moment of starting the turn)
- Turning time (from the moment the head starts to enter the water to initiate the turn, until the contact of the feet with the wall).
- Contact time (from the beginning of the contact of the feet on the wall to the beginning of the impulse).
- Impulse time (from the beginning of the leg thrust to the end of contact with the wall)
- Total time (Time elapsed since the head passes the 7.5 m. line before the wall and the 7.5 m. after the turn).

For the analysis of the proposed indicators, the sports movement analysis *software* Kinovea, see 0.9.3 was used, being possible to control the time spent in each of them. It was possible to obtain the results of the linear velocity expressed in m/s and the acceleration expressed in m/s². A digital stopwatch was used to compare and calibrate the *software in* order to take the total time of the 15 m.

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RESULTS AND DISCUSSION

The following table shows the results obtained for the different indicators during the application of the 15 m. *test* used to evaluate the profitability of the free lap (Table 1).

Table 1. - Results of the evaluated time indicators of the free return

Athletes	Angles °. °	T. Approach.	T. Giro	T. Contact	T. Impulse	Total, time, contact	final 15 T m
1	98	4.34	0.93	0.47	0.23	0.70	10.38
2	112	4.66	1.17	0.07	0.20	0.27	10.49
3	110	4.70	1.40	0.27	0.23	0.50	10.56
4	115	5.01	1.47	0.20	0.17	0.37	10.87
X	108.75	4.68	1.24	0.25	0.21	0.46	10.58
Ds	7.46	0.40	0.18	0.13	0.04	0.16	0.80
	r			-0.87	-0.74	-0.89	0.78

As a relevant aspect, it is emphasized that it is during the impulse where the lowest values of the standard deviation are obtained, which reveals that there is homogeneity in the execution time of this indicator, moment in which the push against the wall occurs, making use of the reactive strength of the legs; adversely, it happens in the total time of the *test*, showing the greatest dispersion, a negative aspect for the achievement of efficient results during the execution of the lap.

Strong correlations were shown between the angles of the legs during the beginning of the wall impulse with the other indicators with negative sense, which explains that as the values of the angles of the legs increase, the contact time and the time of the impulse tend to be lower, not so with the final time of the *test* where the sense of the correlation was positive, which evidences that as the angles formed by the legs during the impulse increase, the time of execution of the 15 m *test* increases.

The angle of the legs formed between the coxofemoral joints, knees and ankles at the beginning of the impulse, was an angle that favored the impulse not to be performed with the required strength, hence the very short contact times with the wall, which was insufficient, and this was reflected in the final result.

It is very common in school categories to start the turn closer to the wall, which may be at an angle between 90° and 110° at the moment of initiating the impulse, which would allow a greater acceleration space, trying to apply greater forward strength during the push to the wall; generally, this is not the case in elite categories, where the leg strengths are more developed and the swimming speed is greater during the approach to the wall. This allows the swimmer to start the turn farther away from the wall and to adopt wider angles, being more efficient in the use of the reactive strenth generated by the leg muscles and thus reducing the time used for the turn (Dies 2015, Skyriene *et al.,* 2017). It is advisable to keep in mind the individual characteristics of the athletes

when establishing the optimal distance to start the turn as a conclusive element for the subsequent impulse (Table 2).

Table 2 - Results of the strength applied during wall impulse

Athletes	Velocity. m/s	Acceleration. m/s²	Quantity Mov kg*m/s	Strength N
1	2.96	9.77	174.64	576.43
2	2.18	10.68	124.26	608.76
3	2.17	9.31	130.20	558.6
4	2.19	8.47	122.64	474.32
X	2.36	9.56	145.27	554.34
DS	0.31	0.80	24.68	1.26
r	0.24	0.96**	0.30	

* Significance level at 0.05
**Significance level at 0.01

Table #2 shows the maximum values of the indicators evaluated during the impulse, as well as the level of correlations obtained between the strengths during the wall push.

As an important fact, it can be seen that the peak values of the kinematic variables of speed and acceleration are reached during the final phase of the impulse, moment in which the predominance of the applied strength corresponds to the reactive explosive capacity of the muscles, a result that demonstrates the importance of keeping in mind during the planning and preparation of the swimmers the development of this capacity. The values of the standard deviation of the strength applied during the impulse are slightly heterogeneous, indicating that there are deficiencies in the reactive strength of the legs, a factor that undoubtedly acts negatively on the result of the return of the lap.

The correlation obtained between the acceleration and the value of the magnitude of strength applied during the wall push is highlighted, which was expressed very strongly in a positive sense, showing that as the swimmer pushes with more strength, an increase in acceleration will develop at the moment of the impulse, which favors greater underwater sliding (Table 3 a and b).

Table 3 - Correlation of the different indicators evaluated with the final result

	Velocity. m/s	Acceleration. m/s²	Strength N	Amount of movement .kg*m/s
r Tiempo final 15 m	-0.61	-0.78*	-0.90**	-0.67

	T. Approach Seg.	T. Giro Seg.	T. Total Contact Seg.	T. impulse Seg.
r Tiempo total 15m	0.96**	0.86**	-0.49	-0.84**

Table 3.a shows the values derived from the correlation between the indicators evaluated and the final result of the *test* that evaluates the profitability of the return.

In the variables strength, speed and acceleration, strong correlations with a negative sense are observed, i.e., the increase of their values leads to a decrease in the execution time of the turn, which indicates, from the perspective of physical fitness, that the power generated by the legs during the push on the wall is an important factor for the achievement of an effective and profitable turn. Therefore, it is necessary to improve leg strength, not only in terms of propulsion performance, a very recurrent aspect in school athletes. General and special exercises for the improvement of leg power should be designed and applied according to the progress of turning profitability.

Table 3.b shows the indicators that evaluate the *test*, where the approach time and the turning time present strong correlations, with a positive sense, demonstrating that as they approached and turned faster, they obtained better final results of the *test.* It can be stated that these two elements were presented with an acceptable level of execution, which made possible the quality of execution of the indicators that followed.

Most of the athletes initiated the turn a little more separated from the wall, favoring the contact time of the feet. This brought as a consequence that the impulse time presented a decrease, compromising the magnitude of f strength applied on the wall, which confirms such approach, the value of the correlations presented in the impulse time and the total time of contact of the feet with the wall, where the correlation was strong, but with a negative sense, which expresses that as the times used for the contact with the wall and the impulse decreased, the total time of execution of the *test* increased. This is very characteristic in school athletes who do not yet have a good development of leg power.

According to the above, the idea that during the turn is one of the moments when the swimmer moves the fastest is reinforced, if we take into account the decrease in speed that occurs during the approach to the wall as a result of the adjustments that swimmers make before starting the turn, which is very frequent in these ages. Absaliamov and Timakovoi (1990) explain that, during the turn and until the beginning of the wall impulse, the swimmer's forward speed becomes zero, however, it is possible to increase the average speed of the displacement during these 15 m., this result materializes during the impulse and subsequent sliding under the water, product of the force exerted by the swimmer's legs against the wall (Veiga and Roig, 2017).

These postulates reflect the poor leg power shown by the group, as expressed in the results of the strength measurement in table #2. Hence, the execution of a turn at the recommended distance, together with the application of good power during the wall impulse, is a determining factor to perform a profitable turn that can positively influence the result of the test.

CONCLUSIONS

In the evaluation of the applied *test*, it was found that there are deficiencies in the application of leg power during the impulse on the wall that led to a lower performance in the profitability of the turn in the swimmers studied.

Very open angles were shown between the hip, knee and ankle joints at the moment of contact with the wall, which favored a very short contact and impulse time, preventing the application of the necessary power for effective underwater sliding.

The leg thrust strength on the wall correlated very strongly with the final result of the 15 m test, suggesting that it is an element to improve, emphasizing leg power as a fundamental way to improve the profitability of the turn.

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Authors' contribution:

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