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Analysis of swimming flip turn kinematic variables of people with disabilities

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Original article

Abstract

Objective: The aim of this study was to attempt to analyse the kinematic variables in the different phases of para-swim turnaround in swimming.

Material and methods: two athletes with disabilities (classes S6 and S14) aged 16 and 21 years were studied. In each subject, three types of somersaults at different speeds to the wall were individually recorded with GOPRO cameras. The videos were processed using Kinovea software.

Results: The phases of the para-swim flip turn were distinguished and the following kinematic variables were analysed: total recurrence time, wall swim speed and rebound speed, distance from the wall, immersion depth and rebound angle. The calculated values of the variables showed individual variation and were related to the type of disability of the athletes.

Conclusions: The pivot phase proper, as the longest part of the para-swimming turnaround, together with the analysis of the variables, allows significant changes to be made in order to reduce the time of the para-swimming turnaround. The defined variables and their interrelationships significantly affect the execution of the turnaround. The angle of rebound and the speed of the athlete's rebound from the wall significantly determine the subsequent course and efficiency of the turnaround. The individualised analysis of the kinematic variables makes it possible to observe the overloads occurring during the para-swimming turnaround and thus enable immediate correction and minimise the risk of negative effects of intensive swimming training.

Keywords

- kinematic analysis
- Kinovea
- para-swimming turnaround
- swimming flip turn
- disability
- swimming

Contribution

A – the preparation of the research project
B – the assembly of data for the research undertaken
C – the conducting of statistical analysis
D – interpretation of results
E – manuscript preparation
F – literature review
G – revising the manuscript

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Introduction

The execution of the kinematic analysis was determined by the fact that there is a wide variety of movement technique presented by swimmers with disabilities. The use of film recording in everyday coaching work is an invaluable aid in the methodology of teaching and perfecting the turnaround. Moreover, it allows an in-depth analysis of the swimmer's skills at each stage of professional swimming training and, extremely importantly, individually adapts the technical abilities to the type of disability of the athlete.

Both the division of the turnaround into phases and the kinematic analysis were performed with reference to the turnaround presented by non-disabled athletes. This turnaround provided a kind of benchmark and a reference point to analyse the movement task performed by swimmers with disabilities. The authors did not have video footage of a healthy athlete. The image of a correct turnaround was developed on the basis of available literature sources, interviews with coaches, as well as the authors' own experience.[1,2]

In the available literature, attempts to analyse the turn itself, the contact with the wall and the so-called 'glide' phase were noted. The execution of the turn in fins has also been studied, as well as attempts to meticulously characterise the execution of the turn.[3] Studies have been produced on the value of hip and knee angles during the turn, and the effect of angle values on the speed achieved after the turn.[4] The topic of the distance from the wall at the start of the relapse, the effect of this value on the size of the angles at the knee and hip joints, as well as on the rebound velocity, has also been considered.[4-6] The methods used by the authors include video-recording, electromyography, dynamometry, and kinematic analysis.[6,7] The group of articles devoted to the relapse is sparse due to the extremely difficult recording, requiring appropriate technology. In the context of this work, an article by German authors was relevant, who, despite making a film recording, were forced to make a qualitative observation of recurrence in the pool.[4] Because the material they recorded was not suitable for the desired measurements. This situation illustrates how difficult it is to perform and analyse this type of research. It should be emphasised that: 'Swimming turns are complex movements that are difficult to analyse without appropriate technology. This fact is due to the characteristics of the water environment, i.e. resistance, refraction and water pressure, but also to the action of the water on several body segments that move in different planes and axes.'[6] All the considerations cited here on the topic of turning refer to healthy athletes. Although Paralympic sport in our country is at a very high level, this is unfortunately not reflected in the amount of research on the same or similar topics.

Purpose

The main aim of the study was to attempt to analyse the kinematic variables in the different phases of para-progression. The authors were also interested in the correlations between the variables in relation to the reduction of time to complete the movement task.

1. An attempt was made to answer the following research questions:
2. Which phases of the para-swimming turnaround have the greatest impact on its total time?
3. Which variables are most important for the efficiency of the para-swimming turnaround?
4. Does individual analysis of kinematic variables identify elements of para-swimming turnaround that expose para-swimmers to overload?

Material and methods

Characteristics of the study group

Four athletes of the Tarnów Disabled Sports Association START Tarnów took part in the study. The athletes were marked with symbols consisting of a letter identifying their gender and a number according to the order of registration. The condition for taking part in the study was the ability to perform a para-swimming turnaround. Competitors were instructed to perform 3 para-swimming turnarounds at different speeds to the headland wall: slow (performing the most technically perfect turnaround, this turnaround is hereafter referred to as 'technical'), fast (a value reflecting the speed usually achieved during training, the turnaround is hereafter referred to as 'fast') and maximum fast (the speed usually achieved during sports competitions, the turnaround of this speed is hereafter referred to as 'sports').

The recorded material was processed using the Kinovea programme. This programme is designed for motion analysis. It allows observation of the recorded image at any speed and specialised comparative analysis of the variables generated from the points marked on the video frames. The length dimension of the plate located on the recurve wall of 23 cm was used to calibrate the image.

Of the examined athletes of the Tarnów Disabled Sports Association START Tarnów, only two athletes whose para-swimming turnaround technique was visually significantly different from that of athletes without disabilities were analysed (Table 1).

Table 1. Physical parameters of the test subjects

	Athlete M1	Athlete M2
Age (years old)	16	21
Body height (cm)	155	187
Body weight (kg)	65	84
Starting group	S6	S14
Training experience (years)	10	11

Source: Authors' own elaboration.

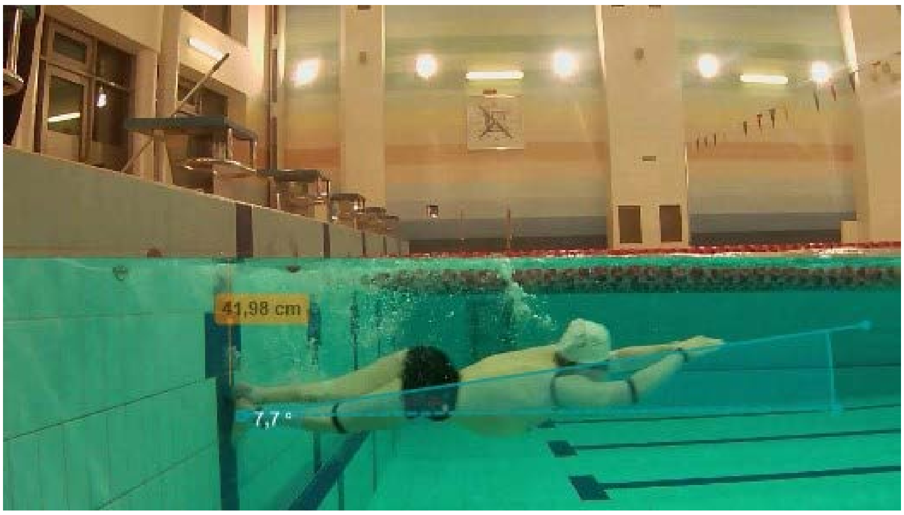
The athletic level of the athletes has been repeatedly confirmed by achieving high results at events of national rank. Both athlete M1 and athlete M2 are multiple medalists at the summer and winter Polish Championships in 2019, 2020, 2021. At the recent Polish Open Winter Championships in swimming for people with disabilities, athlete M1 won a bronze medal, while athlete M2 won a gold medal.

The M1 athlete represented the S6 class. His biggest problem was his lower limb paresis. It prevented him from making propulsive movements during the swim distance as well as during the ascent phase. The athlete therefore only made propulsive movements with his upper limbs, which affected the speed he achieved. Performing a proper turn, as well as a sufficiently strong rebound from the turning wall, was also difficult.

Competitor M2 represented the S14 class. This athlete is slower to learn skills and has difficulty remembering and recreating them. The athlete's focus of attention on the activity being performed is also weaker than that of healthy athletes.[8] When talking to the coaches of the Tarnów club, one repeatedly hears about the slower pace of learning, as well as the necessity to constantly learn the turnaround, resulting from great problems in remembering a specific sequence of movements. The swimmer, despite his great physical disposition, had problems with motor coordination, and recreating several elements in a short time is a challenge for him. For the athlete, the level of stress experienced was very important. Stressful situations significantly affected his concentration, which was a problem when competing or participating in research.

Research methodology

The videos were recorded using two Lamax X 9.1 GOPRO cameras attached with suction cups to the side wall of the pool. The centres of the lenses of both cameras were 0.83 m away from the end wall of the pool, which was used by the athletes to push off with their feet. The above-water camera (No. 1) was placed 3 m away from the test subject and 0.15 m above the water surface. In contrast, the underwater camera (No. 2) was installed at the same distance from the test subject as the first camera and 0.15 m below the water surface. Both devices were perpendicularly aimed at the spot where the athlete performed the essential part of the para-swimming turnaround.



Photography 1. Example measurement of immersion depth and angle of reflection (A. Nosiadek private archive)

The tests were carried out at the Academy of Applied Sciences swimming pool with a 6-lane swimming pool measuring 25 m × 12.5 m. The tests were preceded by an individual warm-up on land and in the water, led by the coach. Before the turnaround, each athlete had anatomical points marked with elastic Velcro bands – these were called markers. These were placed sequentially on the knee and ankle joints in the lower limb and the shoulder, elbow and wrist joints in the upper limb. The hip joint was marked with kinesiotaping tape. Markers had 2 colours, separately for the right and left side of the body (Photo 1).

Research results

The phases of the para-swimming turnaround were distinguished and an attempt was made to detail the kinematic variables describing the para-swimming turnaround and some of their relationships.

Phases of para-swimming turnaround

For the purpose of the analysis, the phases of the para-swimming turnaround were defined, which showed the different elements of the turnaround and allowed for their in-depth analysis. The nomenclature was dictated by the most relevant elements of the swimmer's movement during the para-swimming turnaround (Table 2).

Analysis of para-swimming turnaround variables by phase

The recorded videos were synchronised by combining images from both cameras and then analysed using Kinovea software. The key variables that best characterised changes in position, speed and time were determined in relation to the proposed para-swimming turnaround phases of people with disabilities.

Tabela 2. Characteristics of the phases of para-swimming turnaround

No.	Name of phase	Description
1	Reaching the wall	The start of the phase is when the swimmer's head enters the turnaround zone and then approaches the wall at the distance necessary to perform the turnaround.
2	Initial return	Putting the fingers of the hand in the water during the last arm movement before the turn and preparing the body to start the actual turnover.
3	Actual turnover	Actual turnover begins with a downward bending movement of the head and dipping of the head. The phase lasts from the initiation of the head turn to the contact of the feet with the wall. Behind the arm performing the downward seizure of the water, the head moves together with the torso. This movement may be assisted by a slight dolphin movement of the legs. Once the head is submerged deep under the water surface, the bent lower limbs are thrown over the water and the feet are placed on the wall.
4	Contact with the wall	The beginning is considered to be the first touch of the wall and lasts until the start of the rebound, which is the start of the straightening movement in the knee joints. During this phase, a rotation movement is possible.
5	Rebound	The start is considered to be the beginning of the straightening at the knee and hip joints, and the phase ends with the last contact of the feet with the wall. The arm, which may have remained at the hip, joins the other arm overhead and the starting position for the gliding phase is assumed. During this phase, a rotation movement is also possible.
6	Gliding	The beginning of this phase is the loss of contact between the swimmer and the turning wall until the movement of the limbs begins. During this phase also a rotation movement is possible.
7	Ascent	The start of the phase is considered to be the moment when the movement of the lower or upper limbs begins. The phase ends when the head emerges.

Source: Authors' own elaboration.

Time of individual relapse phasesTime of individual relapse phases

An analysis of the different phases of the para-swimming turnaround in the M1 athlete was carried out against their duration, which is illustrated in the graph (Figure 1).

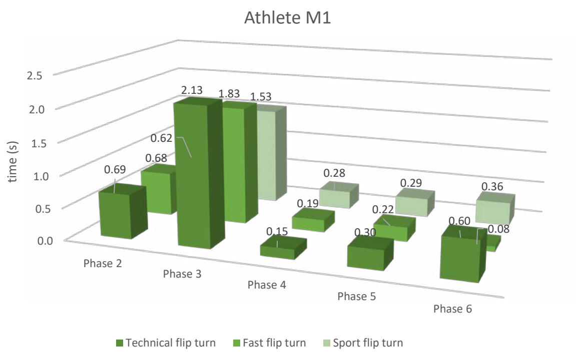


Figure 1. Duration of the para-swimming turnaround phases in the M1 athlete

A similar analysis as above was carried out for the second athlete, compiling the durations of the different phases in relation to the type of recurrence (Figure 2).

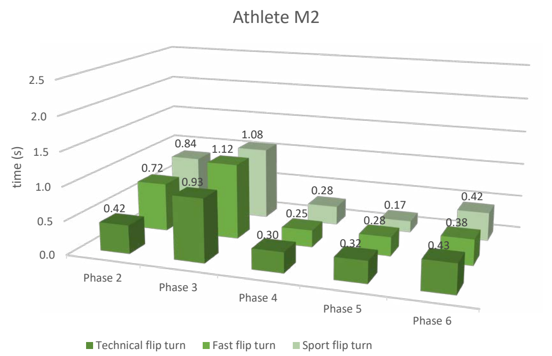


Figure 2. Duration of para-swimming turnaround phases in the M2 athlete

Analysing the recorded material in both athletes, it was observed that the longest lasting phase was the proper rotation phase (phase 3). Individually, for athlete M1, the wall contact phase was the shortest, while for athlete M2, it was the rebound phase that was the shortest.

Total turnaround time

One of the most important variables determining the time gain after a para-swimming turnaround is the value of the total turnaround time. Unfortunately, the scope of the recorded material did not cover the first and last phases in their entirety, so that only the summed time of only five phases (2–6) was included in the analysis. It is surprising that the total turnaround time is not the shortest during the sport turnaround. Athlete M1 obtained the shortest of the times in question during the fast turnaround, while athlete M2 obtained the shortest during the technical turnaround (Figure 3).

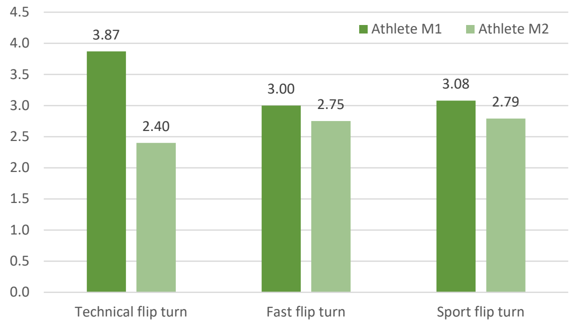


Figure 3. Total turnaround time [s]

Speed of arrival at the wall and speed of rebound

A compilation was made of the maximum speeds at which the athletes approached the para-swimming turnaround and immediately afterwards. As the phases of reaching the wall were not recorded in their entirety, the speeds the athletes had just before the start phase of the turnaround were taken into account.

The speeds of the two athletes were clearly different and the M1 athlete performed significantly slower both the swim to the wall and the rebound itself. The speeds achieved by the athlete were similar regardless of the type of turn performed (technical, fast, start). However, the greatest difference between speeds occurred during the technical turn, when the speed of the swim to the wall was the lowest, while the speed of the rebound reached the highest value among all three types of turns (Figure 4).

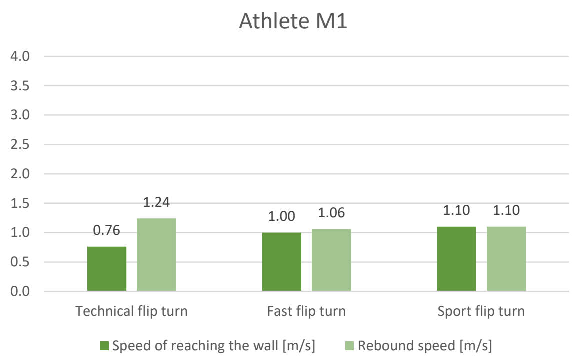


Figure 4. Summary of speed in the M1 athlete

Significant differences between the two speeds were observed for the second athlete. At the technical turnaround, the rebound speed was lowest, while the highest rebound speed was achieved by athlete M2 during the sport turnaround (Figure 5).

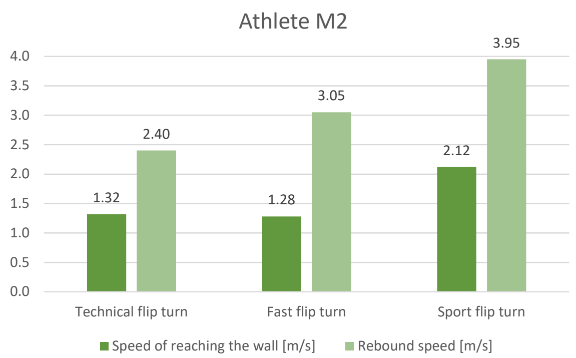


Figure 5. Summary of speed in the M2 athlete

Distance from the wall and speed of rebound

In athlete M1, the highest value of rebound speed was observed at a distance of 0.69 m from the turning wall. Both at a greater distance from the wall and at a shorter distance – the rebound speeds were lower (Figure 6).

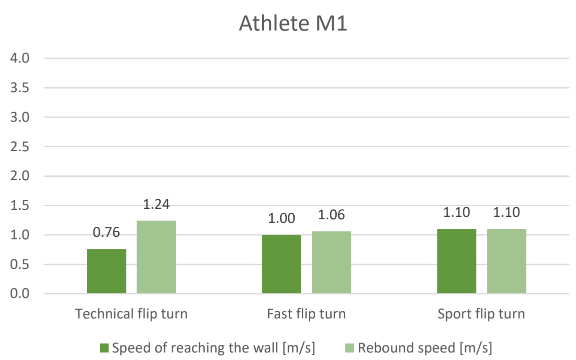


Figure 6. Distance from the wall and speed of rebound in the M1 athlete

Similar relationships between variables were observed for the second athlete. A distance of 0.85 m from the recurve wall, allowed athlete M2 to achieve the highest rebound speed, while a shorter or greater distance gave lower speed values (Figure 7).

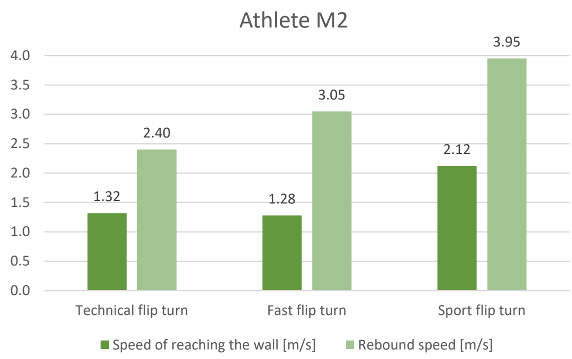


Figure 7. Distance from the wall and speed of rebound in the M2 athlete

Rebound angle versus rebound speed

During the rebound from the turning wall, the angle between the long axis of the swimmer's body and the straight line parallel to the water surface was measured. The two swimmers differed markedly in their technique of performing the turnaround, which was particularly highlighted by the value of the rebound angle from the turnaround wall. The former achieved positive values and rebounded towards the surface, while the latter had a negative rebound angle value, indicating a rebound towards the bottom.

Despite the decreasing rebound angle, the rebound speeds of the M1 athlete were similar to each other, in each of the three types of recurve (Figure 8).

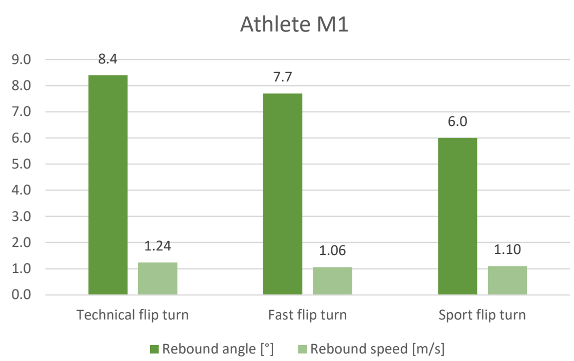


Figure 8. Rebound angle, and rebound speed in the M1 athlete

Player M2, bouncing towards the bottom, achieved a very good rebound speed. The smaller his rebound angle was, the higher the rebound speed obtained (Figure 9).

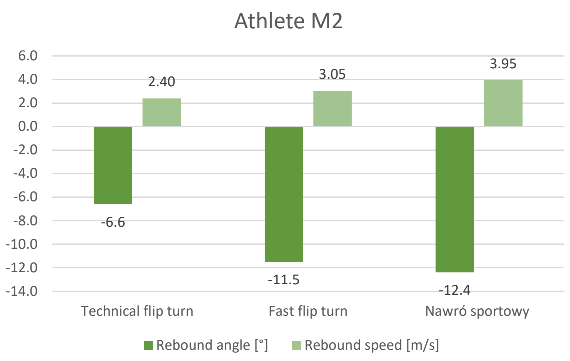


Figure 9. Rebound angle, and rebound speed in the M2 athlete

Depth of immersion and rebound angle

Immersion depth was determined by the distance of the nearest point of the foot to the water surface at the moment of contact with the turning wall. In both athletes, the greatest immersion was observed at the technical turnaround and the smallest immersion was observed when performing the sport turnaround.

The M1 athlete dipped significantly deeper during the turnaround than the other athlete. With his increasingly shallow immersion, a decreasing rebound angle from the wall was observed (Figure 10).

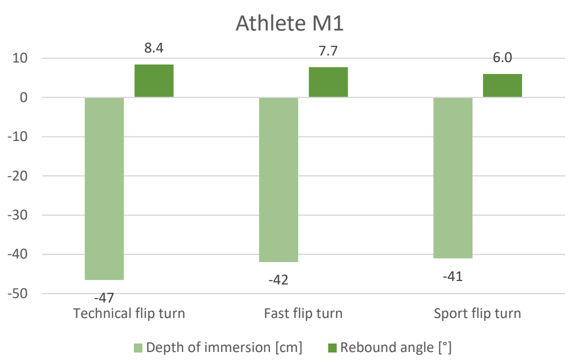


Figure 10. Depth of immersion and rebound angle for the M1 athlete

Competitor M2, as the depth of immersion decreased (shallower and shallower), increased his rebound angle further and further towards the bottom (Figure 11).

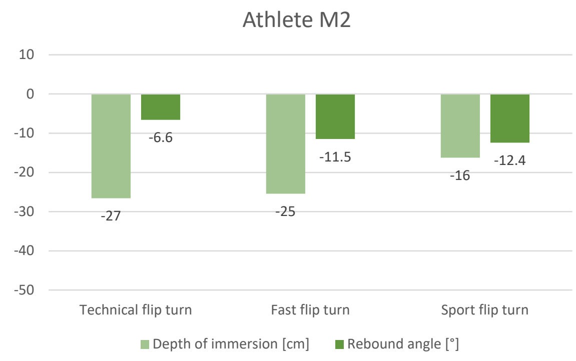


Figure 11. Depth of immersion and rebound angle for the M2 athlete

Discussion

The kinematic analysis of the variables describing the para-swimming turnaround, which was carried out, made it possible to identify in detail those factors that significantly influence the most favourable execution of the movement task.

It is important to emphasise the fact that even within groups of the same sports class, there is individual dysfunctional variation that certainly affects the technique of performing the para-swimming turnaround. The analysis attempted is therefore the beginning of a discussion, with the aim of identifying some regularities that can be observed in a wider range of athletes.

Individual variation of para--swimming turnaround phases

Champion swimmers set the standards for the technique of their movements, which sporting rivals trying to match them try to emulate. Research has confirmed that people with disabilities often rely on their own observations and adjustments in terms of their abilities and individual psycho-motor limitations. In order to gain a detailed insight into the presented technique for performing the para-swimming turnaround of the athletes studied, the movement task was divided into seven phases.

Phase 1 – reaching the wall

Swimmers who struggled with different types of dysfunctions modified the distance from the wall, thus compensating for their limited mobility, and thus the appropriate distance facilitated their execution of the turnaround. The speed at which the swimmer swam to the turnaround wall had a direct impact on the quality of the turnaround performed. A high speed of the swimmer's arrival at the wall provided the opportunity for a strong and effective rebound. On the other hand, too low an inbound speed could have made it difficult or completely impossible to perform the turn proper. 'In general, it can be assumed, according to the laws of dynamics, that the higher the speed of the swimmer to the wall, the potentially faster the speed from the wall should be. This means that a swimmer who attacks the wall at a faster speed performs the turn itself more dynamically, although this does not necessarily translate directly into rebound power.'[2] Achieving a high speed to the wall posed a problem for the M1 athlete, who swam using only the propulsive power of the upper limbs. The swimmer's lower limbs, which remained immobilised in a flexion contracture, resisted the water, making it even more difficult for the athlete to move.

Phase 2 – initial return

The time that elapsed between the last time he put his hand in the water and the start of the downward movement of his head – the swimmer used to correct the distance to the turning wall. Sometimes he would lift his head to visually assess this distance, which obviously reduced his speed towards the wall.

Phase 3 – actual turnover

During this phase, it was possible to start the rotation movement of the swimmer's body (twist). The turn and its continuation could also take place in subsequent phases. On the basis of the research carried out, it can be assumed that while the athlete was approaching the wall at a high speed it was necessary to initiate the turn at a greater distance from the wall. It happened that the legs thrown over the turning wall acted as a shock absorber, slowing down the speed and allowing the turning to continue. These actions increased the total turnaround time. When the athlete swam at a lower speed, it was necessary to initiate the turnaround closer to the wall, allowing for a sufficiently strong rebound, despite the low speed of the swim to the wall. In the literature available to the authors, information on the duration of the actual turnover was encountered: 'The turnaround phase is designed to bring the lower limbs to the wall as quickly as possible;'[2] 'The period from the insertion of the hand into the water of the last movement before the recurve to the contact of the feet with the wall did not last longer than 0.6 seconds.'[9] After analysing the recorded material, we know that the actual turnover phase was the longest phase for athletes with a disability, while the statements quoted highlight the importance of the short duration of this phase. Therefore, we can surmise that phase 3 was the most important phase for the athletes with disabilities, and its continuous improvement could significantly affect the reduction of the total turnaround time. Thus, the most important phase of the turnaround for swimmers with a disability was different to that of swimmers without a disability. 'Of particular importance, however, is the initial phase and the bounce off the wall.'[1]

The actual turnover was longest for athlete M1. This athlete carried his lower limbs in a high arc over the water surface, which may have had a significant impact on the actual turnover time he achieved. Another important aspect was the work of the upper limbs during this phase. During actual turnover, the upper limbs should be joined overhead and the swimmer should assume a position that prepares him/her to bounce off the wall. On the recorded material, it was observed that the M1 athlete used the upper limbs to facilitate the execution of the actual turnover. This posed a major problem, through which the athlete lengthened the time of the actual turnover phase.

Phase 4 – contact with the wall

The swimmer's contact with the turning wall was a very important element of the turnaround, closely related to the speed of the swimmer's arrival at the wall, as well as the depth of immersion – as manifested by the distance of the foot placement on the wall below the water surface. Often, in this one of the shortest phases, the angle at which the test subject would bounce was decided, as well as the speed at which they would bounce off the wall. Some of the authors emphasise the importance of the duration of this phase, stating that the contact of the feet with the wall must not be too short and must last approximately 0.5 seconds in order to make full use of the leg strength in an effective rebound.[2] In a further study by this author, the relationship between the duration of foot contact with the wall and the degree of flexion of the lower limbs was recognised.[2]

Phase 5 – rebound

In order to achieve an effective rebound, the lower limbs had to be properly flexed. It was not possible to achieve a powerful rebound with straight limbs. The distance from the wall therefore determined the ability to achieve a high speed rebound. If the athlete was limited by the ability to flex the lower limbs, both the distance from the wall and the rebound speed achieved were similar despite the different speed of the swim to the wall. This phase was particularly difficult for the M1 athlete. The paresis of the lower limbs resulted in poor and ineffective rebounds from the return wall.

Phase 6 – gliding

Gliding is referred to as the free movement of the body immediately following a bounce off the recurve wall. In the recorded footage, the very short gliding time presented by the athletes with disabilities was noted. Practically immediately after losing contact with the wall, they proceeded to perform propulsive movements. If the swimmer's propulsion was solely the upper limbs, the athlete was trying to get near the surface in a relatively short period of time in order to put them to work as quickly as possible, which could clearly be seen in the M1 athlete. The positioning of the swimmer's body was also extremely important during the glide phase, so that a strong rebound would translate into a large propulsive impulse. Furthermore, the body during the rebound and during the subsequent lunge should assume as streamlined and hydrodynamic a position as possible.[2]

Phase 7 – ascent

Accumulation of errors during the earlier phases could result in diving too deep and having to make propulsive movements towards the water surface. The ascent phase then lasted longer and was usually a correction for misjudging the distance to the wall. If the athlete turned close to the water surface, after rebounding towards the bottom, he or she could use the ascent phase to activate the lower limb drive and possibly rotate the body (from supine to breaststroke).

However, the observations of each phase described above did not answer the research questions posed, so the authors of the study compared some of the variables with each other in an attempt to find some relationships between them.

Kinematic variables and their influence on swimming turnaround

The turnaround is a complex activity, the success of which depends on the perfect execution of its component parts. The different phases of the turnaround were closely linked to each other. Reducing the speed of the swim to the wall, diving too deep or the rebound angle from the turning wall, could result in the loss of precious seconds, which could no longer be made up during the turning itself.

For swimmers with disabilities, the actual turnover phase was the phase they modified the most. For the athletes, it was the most difficult phase and took them the longest time. Increasing the duration of this phase resulted in acquiring too little energy necessary to perform the rebound, which in turn resulted in a deep dip and a long contact time between the athlete and the turning wall. A poor rebound means that there is not enough energy to enable a correct and efficient glide. As a result, the gliding phase was shortened, which in turn translated into a marked decrease in speed after the rebound from the headland wall. As a result, the last phase (ascent phase) was started far too early.

In both athletes tested, similar proportions of time per phase were observed. The longest lasting phase was the actual turnover phase (phase 3), while the shortest phase was the wall contact phase (phase 4).

The fact that the total turnaround time (summed time of phases 2–6) was not the shortest during the sport turnaround may have been due to the type of disability of the athletes. In the first athlete, a paresis of the lower limbs caused a complete loss of propulsion at the start of the actual turnaround – hence it was extremely important for the athlete to judge the distance from the wall. This determined the speed at which the athlete reached the wall and therefore it was easier for the athlete to execute the turn at training speed, during which he acted in a learned manner. The second athlete, despite the different types of turns assumed by the authors of the study, as a result of his intellectual disability, performed all three turns similarly, most likely without understanding the command exactly. Therefore, it was necessary to search for correlations by comparing the individual values of the kinematic variables.

The type of disability definitely affected the speeds achieved. The M1 athlete, who only used his upper limbs as propulsion, achieved significantly lower values for speed to the wall than the M2 athlete. The disproportion was even more pronounced in the rebound speed, where the limited possibilities of rebounding from the wall resulted in similar speed values. In athlete M2, it was noted that he achieved the highest value of rebound speed after he had reached the wall. Therefore, he certainly used the energy from braking with his feet on the wall during the turnaround and the increased rebound ability.

Taking into consideration that for the M1 athlete, who had a low speed to the wall, the distance from the wall at the start of the turnaround was important, the mentioned distance was compared together with the rebound speed. It turned out that for both athletes there was a certain optimum distance that resulted in the highest rebound speed value. A smaller or larger starting distance of the turnaround resulted in a decrease in the value of the turnaround speed.

An interesting relationship was observed between the rebound angle and the rebound speed obtained. The M1 athlete, with a limited ability to bounce off the wall, increased his rebound speed by directing it decisively towards the surface. It is possible that the deep immersion and increased buoyancy force became an additional factor in increasing speed. Competitor M2, on the other hand, using the strength of his lower limbs, achieved the highest rebound speed when directed as vertical as possible to the water surface.

As the rebound angle differed significantly between the two athletes, it was compared with the depth of submersion of the athletes. The significant immersion depths in the M1 athlete, was due to the lower speed and supportive work of the upper limbs during the actual turnover, which, by assisting the rotation, directed the swimmer's body deeper underwater. The inability to use the lower limbs as propulsion during the glide and ascent phases determined the athlete to shorten these phases and take the direction of the rebound towards the surface. A completely opposite relationship was observed in the second athlete, who, in order to use the propulsion of the lower limbs during the subsequent phases, the shallower he went, the greater the angle at which he rebounded towards the bottom of the pool.

'From the beginning, sport for people with disabilities has primarily emphasised its health and healing function and integrates the community of disabled and non-disabled members of society.'[5] Over time, the development of Paralympic sport has become increasingly dynamic. This has caused a gradual blurring of the boundaries between competition between athletes with and without disabilities. Activities initially aimed mainly at the rehabilitation of people with disabilities gave rise to rivalry and competition.

The training plan of an athlete with a disability should be as individual as possible.[11] It should not only include activities aimed at achieving a certain sporting level. It is extremely important that the training plan includes activities aimed at preventing overload and excluding the risk of injury as much as possible. 'In the case of people with disabilities, the possibility of participating in various manifestations of physical culture is determined by the specificity of the incapacity, and whatever the form of this participation, a therapeutic goal will always be manifested in it.'[12]

The individual analysis of the kinematic variables provided the opportunity to obtain accurate values for specific parameters. This made it possible to control the loads involved and, most importantly, to detect their possible negative impact on the athlete's functional capabilities.

Conclusions

1. During para-swimming flip turn, the actual turnover phase lasted the longest. However, on the basis of the results obtained, it is not possible to clearly indicate which phase is most important for reducing the total time of recurrence.
2. Rebound angle and rebound speed are variables that significantly determined the course as well as the efficiency of the swimming turnaround of the para-swimmers tested.
3. Individual analysis of kinematic variables can be used to observe overloads occurring during the swimming turnaround. Their detection allows immediate correction and minimisation of the risk of negative effects of intensive swimming training.

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