



REVIEW PAPER

Kinematic analysis of elite Portuguese swimmer with loco motor disability between Charcot-Marie-Tooth disease and arm amputees - Review study

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Abstract

The aim of this study was to compare biophysical characteristics of Paralympic swimmers. This case study includes two swimmers with loco motor disability classes S9, according to functional classification by international Paralympic committee – IPC. These swimmers completed a 7 x 200m crawl stroke protocol with increasing speed 0.05 05m s⁻¹ in each level and 30s interval. Interval speeds were based on 400m race speed. VO₂ consumption was measured each 200 meter directly and continuously with a telemetric portable gas analyzer (K4 b2, Cosmed, Rome, Italy) connected to a respiratory snorkel (AquaTrainer Snorkel, Cosmed, Rome, Italy). The trails were recorded on 6 video cameras each 200m swim. If the swimmer reached the Lactate plateau before completing the seventh repetition, the test was stopped. Test showed that CMT swimmer achieved a lower oxygen consumption than amputee swimmer when they reach their max speed. Video analysis of 17 and 18 body segments helped us to define some stroke parameters. Results indicated that the right arm showed larger joint angle than left. Also, amputee swimmer had larger linear displacement. Swimmers performed active drag test $10 \pm 1.3s$, vertical 5.4 ± 1.4 horizontal floating time 6.5 ± 1.5 and glide distance $6.6 \pm 0.5m$.

Keywords: *biomechanics, front crawl swimming, loco-motor displacement*

Introduction

The International Paralympic Committee (IPC) is the global governing body of the Paralympic Movement, as well as the organizer of the Summer and Winter Paralympic Games. There are 20 Summer Paralympic sports, and four Winter. In November 2007 the General Assembly of the IPC approved the IPC Classification Code. The Classification Code of the International Paralympic Committee (IPC), inter alia, mandates the development of evidence-based systems of classification (Tweedy et al., 2011).

Classification is a process in which a single group of entities (or units) are ordered into a number of smaller groups (or classes) on the basis of observable properties that they

have in common. Taxonomy is the science of how to classify, its principles, procedures and rules (Fleishman et al., 1984). It is applied in most scientific fields to develop systems of naming and ordering that facilitate communication, understanding and identification of inter-relationships. Competition is a defining feature of sport and one of several factors that differentiates sport from other physical activities such as exercise, activities of daily living or recreation (Australian Bureau of Statistics 2008). Moreover, competition is known to be a potent social factor that motivates many thousands of people to play sport (Vallerand et al., 2001). However, when competition is one-sided or predictable, motivation to participate in sport is reduced, particularly among the

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unsuccessful. Classification in sport reduces the likelihood of one-sided competition and in this way promotes participation. Paralympic systems of classification should indicate that the purpose of the system is to promote participation in sport by people with disabilities by minimizing the impact of eligible impairment types on the outcome of competition (Tweedy et al., 2011).

Swimming caters for three impairment groups - physical, visual and intellectual. The sport class names in Swimming consist of a prefix "S", "SM", or "SB" and a number. The prefixes stand for the event and the number indicates the sport class the athlete competes in the respective event. The prefixes stand for: S: Freestyle, Butterfly and Backstroke events; SM: Individual Medley and SB: Breaststroke (Official website of IPC, 2013). All visually impaired competitors shall be classified by an authorized ophthalmologist authorized by the International Blind Sports Association (IBSA) Classification Officer and IPC Swimming. All swimmers with an intellectual disability whose eligibility has been determined and endorsed in their native country and these details acknowledged and confirmed by the International Sports Federation for Persons within Intellectual Disability (INAS-FID) shall be eligible to participate. These swimmers will be referred to as class S14. The classification system uses a numerical calculation of locomotors ability as a guideline and is expressed in figures showing the variation in propulsion effectiveness of swimmers with different locomotors abilities (amputees, cerebral palsy, dysmelia, les autres, spinal cord injury and polio swimmers) (International Paralympic Committee, 1998).

This research need to see biophysical characterization and to make difference specifically between swimmers who compete in the same class, and compare their results with swim-

mer who is in S9 swimming class. Swimmers with loco motor disability will be subjected for this research. Goal of this research is to see bio-mechanical characteristics of Paralympic swimmers. Main goal of this research is that the developing of aquatic motor skills showing how stroking parameters (velocity, stroke length and stroke rate) and inter-arm coordination in front crawl need to be monitored simultaneously both in able-bodied and swimmers with impairment. The goal of all competitive swimmers is the same, e.g. overcoming aquatic resistance to swim faster. Both able-bodied and swimmer with impairment need to organize their body and limb coordination and position optimally (Seifert et al., 2009).

Method

For collection of the studies examining the kinematic and biophysical characterize between different impairment. I searched the following electronic databases: PubMed / Medline, Pedro, Issue, DOAJ, Google scholar, Limo. Searched papers in period from 2000 - 2014. For searching the databases I used following keywords: aerobic capacity, Paralympic, physical activity, classification, Charcot-Marie-Tooth, swimming, kinematic, Vo2max, amputees. All researches that I found were full read and analyzed (Table 1). In order to explore all researches they need to fulfill two specific criteria: researches need to have experimental group between 18 and 35 years, and consider at least one swimmer who competes in the S9 classification group. Research which established main criteria (6 research) was analyzed and presented based on the following parameter: reference (first letter of the author and the year of the publication of the research, sample of respondents, program of research training and duration of the program and results of the research).

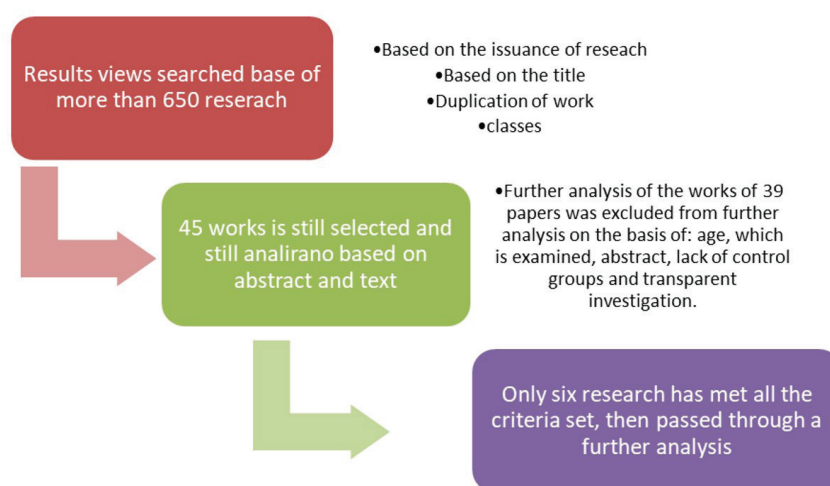


FIGURE 1. Search process

Results

Table 1 shows the results of the research.

Table 1. Tabulation of included studies that compare Paralympic swimmer with different impairment also includes S9 Paralympic class

Reference	Population	Comparison group	Treatment	Result of research
Daly et al., 2003	72 male swimmer and 62 female finalists at the Sydney 2000 Paralympic Games.	All Paralympic swimmer with physical problem who compete from in class S2 and S10	100m freestyle performances	For both men and women, the CV increased from heat to final. SR was more responsible for changes in the first part of the race, while SL (or maintaining SL) was responsible for changes at the end of the race

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Reference	Population	Comparison group	Treatment	Result of research
Satkunskiene et al., 2005	9 females 9 males	Swimming functional classes S3 – S10	100m freestyle race	Swimmers with loco-motor disabilities increase velocity by increasing stroke rate (especially in lower functional classes), because they do not exploit the push phase effectively.
Daly et al., 2006	Swimming events were videotaped at the Atlanta and Sydney Games.	All Paralympic swimmer with physical problem who compete	50 – m freestyle finalists 100- m freestyle finalists 400– m freestyle finalists	1. In the 50-m sprint SR drops and SL increases as the race progresses. 2. In the 100-m race SR decreases from the first to second segments and then stabilizes dropping slightly in the CP swimmers. 3. SL increases and then decreases at 400-m and SR drops slightly in the beginning of the race, stabilizes and then increases slightly at the end. SR may not be as important as SL for swimmers between S7 and S10 class.
Seifert et al., 2009	Data collected from elite competitions (Olympic and Paralympic Games)	Olympic Paralympic participants	100m freestyle finalists	Correlations suggest that S7-S10 swimmer do not possess the same skill level for start, turn and finish time and suggest that different strategies are evident between Paralympic swimming classes. They found that races were won or lost by better maintaining velocity in the second half of each 50m race
Marques et al., 2014	S9 Paralympic swimmer	One S9 Paralympic swimmer with CP	6x200m front crawl incremental protocol Vo2 max	Generally information about CP swimmer S9 classification group.
Stefka et al., 2014	Sixteen Paralympic swimmer with CP and sixteen swimmer with limb loss	1.EXP (n=16) 2.CON (n=14)	1.100 meter swim race	EXP: SR↓ Than CON 3 and 4 segment of the race EXP ↓ than CON

Legend: CG- Control group EXP- experimental group; CP – Cerebral palsy SR - stroke rate CV - coefficients of variation SR – stroke rate SL – Stroke length VO2max – Maximal oxygen uptake

Discussion

Satkunskiene et al., (2005) reported that “more-skilled” swimmers, with various locomotors disabilities, were characterized by greater amounts of superposition and higher stroke frequencies, when compared to “less-skilled” swimmers. Other authors have also shown that stroke frequency significantly correlates with arm coordination (Chollet et al., 2000; Seifert et al., 2004). Seifert et al., (2009) suggest that S7-S10 swimmer do not possess the same skill level for start, turn and finish time and suggest that different strategies are evident between Paralympic swimming classes. Pelayo et al. (1999) found that high-end values in training volume and intensity of male competitive swimmers with a locomotors disability were greater than in women, although mean values were similar.

Osborough et al., (2009) they found that swimmer with a single arm amputation, consequence of being deprived, and stroke rate is more important than stroke length to maintained fast velocity. The fastest amputee’s affected-arm spent less time in the Entry and Glide and Recovery phases and more time in the Pull and Push phases, when compared to the slower swimmers. For able-bodied swimmers (Chollet et al., 2000) and swimmers with a locomotors disability (Satkunskiene et al., 2005) higher IdC values and higher stroke frequencies were significantly related to shorter Entry and Glide phase durations and longer Pull phase durations. Fernandes et al., (2008) in this study was measure, in swimming pool conditions and with high level swimmers, the time to exhaustion at the minimum velocity that elicits maximal oxygen consumption (TLim at vVO2 max), and the corresponding VO2 slow components (O2SC). VO2 was measured through direct oximetry and the swimming velocity was controlled using a visual light-pacer.

Special purpose of this study was to assess, in free swimming conditions and with high level swimmers, the time to exhaustion at the minimum velocity that elicits VO2 max.

When sprinting, the fastest swimmers used higher stroke frequencies and less catch-up of their affected-arm, when compared to the slower swimmers. These findings imply that: (1) unilateral arm amputee front crawl swimmers use an asymmetrical strategy for coordinating their affected-arm relative to their unaffected-arm in order to maintain the stable repetition of their overall arm stroke cycle; and (2) when sprinting, the attainment of a high stroke frequency is influenced mainly by catch-up style of the affected-arm. For these swimmers, reducing the time delay (i.e., the Entry and Glide phase duration) before initiating the affected-arm pull appears to be a beneficial strategy, which allows for the attainment of the highest stroke frequencies and swimming speeds (Osborough et al., 2010). When swim velocity increased the pull phase increased and entry phase decreased showing their relative incapacity to adapt their technique to biomechanical constraints (Seifert et al., 2003). The behaviour of the biomechanical parameters corroborate the literature (Osborough et al., 2010), evidencing that the amputee swimmer increased velocity by augmenting FG and decreasing DC. However, the intracyclic velocity variation (IVV) values were higher than to those described for the swimmers without disabilities.

Conclusion

None of the studies present difference between a swimmer with the Charcot-Marie-Tooth disease and a swimmer with arm amputees who compete in the same swimming classes. With research Vilas-Boas et al., (2001) we can see the differ-

ence between propulsion and how much impairment can have positive or negative influence on their swimming performance. When we speak about the drag in the water, in research Havriluk et al., (2005) finding that the faster swimmers had a lower coefficient of drag than the slower swimmers supports the hypothesis that faster swimmers have a more hydro dynamically effective streamline. Lot of the studies compare different classes and impairment and they find how much each of them is different during swimming process. This study has a plan to see that difference and get new information how difference between two impairments during swimming had influence on their performance. Results need to show us how much one disability has advantage over another in the competitive swimming. This study needs to present and find difference in the stroke rate, length, velocity, active, passive drag and Vo2max what researchers try to inform us. With all this knowledge we can see if someone of these swimmers has advantage over another and where is that advantage. With kinematic analysis we can see how much is the oscillation in the stroke rate and propulsion between two of them. Stefka Djobova & Daniel Daly (2014) can help us to see how much each of this impairment is different between each of swimmer. For example in this article gave us nice view about CP and difference between different classes and different impairment. Here we can see if classification benignly to another impairment and in which phases during swimming. Bio-mechanical characteristics of the physical impairment swimmers are not well known. Future studies will contribute to a better process of classification of these swimmers by The International Paralympic Committee. New analysis also needs to support and develop specific training methods to increase swimmers performance. One of the main ideas of this paper is to get information of the rules of classification and with that information make them even better than now if is that possible. People need to have same rights and rules which must be observed in order to create equality among disabilities so as not to have any advantage over other participants.

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