Santos J, Dias G, Couceiro MS, Mendes P, & Santos AC. Influence of the physical fitness, anthropometry profile and body composition on sailing performance
J Sport Human Perf 2016; 4(1):1-17.

JOURNAL OF SPORT AND HUMAN PERFORMANCE

ORIGINAL RESEARCH OPEN ACCESS

INFLUENCE OF THE PHYSICAL FITNESS, ANTHROPOMETRY PROFILE AND BODY COMPOSITION ON SAILING PERFORMANCE

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ABSTRACT

This study aims to analyse the influence of physical fitness, the anthropometric profile and the body composition on performance at the start of sailing regattas. We analysed ten sailors, each using an Optimist type boat, all male, aged 11.80±1.40 years, with 4.60±2.12 years of experience (Portuguese national ranking), with 44.35±9.30 kg body mass and 153.41±8.49 cm height. The experimental task consisted of performing six starts and sail through a predetermined route. Two digital cameras recording at 25 Hz were used to collect data on athletes' positioning and location in all regattas. To analyse the physical fitness, the anthropometric profile, and the body composition of sailors, Fitnessgram tests were considered. Additionally, this work uses of fuzzy logic to estimate the score of each athlete by combining several inputs, namely the bioimpedance and others retrieved from the fitnessgram tests. Results indicated that body mass is significantly related to the sailing performance. This variable was shown to be very important for the sailor to be able to cope with strong winds and other constraints faced during the sailing. We concluded that sailing in high-winds requires great skill and physical effort to control the boat. For this reason, it seems that heavier athletes tend to better deal with different wind intensities, better adapting their performance to the boat manoeuvres.

Keywords: starting sailing regattas; physical effort; fuzzy logic; performance

INTRODUCTION

Sailing has become a highly complex sport where numerous factors affect the performance. Athletes must identify the various competition parameters, like boat handling, gear development, as well as technical and tactical understanding. Also, physical fitness and muscular strength have become important factors for performance optimization (Bojsen-Møller et al., 2007, Pulur, 2011).

The intensity in sailing varies greatly and is influenced by the boat, the environment and the athlete's skills (Neville et al., 2009). Sailing in high-winds requires great skill and physical effort to control the boat (Gore, 2000, Pulur, 2011). In that sense, Legg et al. (1999, 2000) found that some sailors exhibited significant changes in flexibility, skinfolds, body weight, aerobic endurance and strength.

Providing further contributions to these theoretical assumptions, authors such as Maïsetti et al. (2002), Legg and Park (2003), Benardi et al. (2007), and Allen and Jong (2011), argue that sailors' motor skills are essential for them to appropriately respond to wind changes during regattas, thus allowing them to better meet the environmental constraints emerging from this sport (e.g., wind changes). This is important because sailors can spend up to 94% of their time hiking with strong winds, having to withstand physical and mental fatigue, which requires a high aerobic capacity (Allen & Jong, 2011).

In spite of this, Castagna and Brisswalter (2007) indicate that during a test in the Laser class, the sailor mainly uses aerobic pathways. From this perspective, aerobic training has been shown to be directly related to a sailor's reaction speed to wind shifts, as well as overall decision-making, enhanced endurance and concentration (Zelhof, 1991, Shephard, 1997, Legg et al., 1999, 2000, Bojsen-Møller et al., 2007, Neville et al., 2009, Pluijms et al., 2013). Additionally, muscle endurance, strength, power, cardiovascular fitness, weight management and agility play important roles in sailors training regimens (Cunningham, 1996). For these reasons, both physical fitness and the anthropometric profile of young sailors have been jointly considered the key performance indicators in regatta (cf. Legg et al., 1999, Moller et al., 2003, Bojsen-Møller et al., 2007 and Neville et al., 2009).

As previously stated, the literature shows that only a small number of studies tried to relate sailors' physical characteristics to their racing performance (Legg et al., 1999, 2000). For instance, Hadala et al. (2012) indicate that body anthropometrical characteristics were significantly related to sailing performance. For these authors, sailing teams select athletes with anthropometric dimensions better suited to improve the performance during sailing manoeuvres, enhancing their likelihood of competitive success. On the other hand, Araújo et al. (2014) indicate that analysis of sailors control of boats at the start of regattas reveals that, although decisions regarding the discrete optimal starting place could be made in advance, this tactic is inherently misleading because of the need to consider and interact with instantaneously changing tasks and environmental constraints. For these authors (2014), constraints include wind direction, the ebb and flow of ocean currents, and opposition boats trying to keep or gain a positional advantage over the others. In other words, one needs to understand the nature of the behaviours that emerge in order to obtain information about adjusting the sailors underlying performance strategy (Araújo et al., 2006).

Following this idea, this work aims at verifying if whether or not the sailors' physical capabilities are important for an appropriate response to wind changes and the constraints involved in the competition (Tan & Sunarja, 2007, Oliveira et al., 2011, Allen & Jong, 2011). To do so, we will analyse the influence of physical fitness, the anthropometric profile, and the body composition in the performance at the start of sailing regattas.

METHODS

Ten sailors, male, aged 11.80±1.40 years, with 4.60±2.12 years of experience participated in the study (Portuguese national ranking), each using an Optimist type boat. The ethics committee of the Faculty of Sport Science and Physical Education of Coimbra granted ethical approval for the study.

The experimental task consisted of performing six starts and a predetermined route on a single sea field, which was shorter than the official International Optimist Dinghy Association (IODA), in the fastest time (time trial). The performance evaluation was based on the results of the six starts, classifying the performance of practitioners by the number of points obtained (total of 54 points) (see Santos et al., 2013 for a review). In addition to the performance assessment of sailors, their end position was recorded in all regattas and a ranking of end position of regatta was assigned (i.e., the sum of the sailor arrival classifications in each of the 6 regattas). The higher the score, the better the position on ranking.

Two digital cameras, recording at 25 Hz, were used to collect the positional data of athletes in all regattas. One digital camera Go Pro Hero 1 was placed on the pin start (i.e., aligned with the starting line), which recorded the start and finish of each Optimist. A second digital camera Canon EOS 550D was placed on the ground, in order to obtain a plane / broad angle of the field sea at the moment of starting.

To analyse the physical fitness, anthropometric profile and the body composition of sailors, Fitnessgram tests were used according to the following protocols: 1) abdominal strength and endurance (curl up), 2) flexibility (back-saver sit and reach), 3) trunk extensor strength and flexibility (trunk lift), 4) upper body strength and endurance (90º push up). Finally, to measure the aerobic capacity, we applied the PACER/Yo-Yo test (see Meredith & Welk, 2013, for a review). Participants were familiar with the protocols since the tests are included in the Portuguese physical education curriculum as part of the Fitnessgram test battery (Sardinha, 2007, Coelho e Silva et al., 2008).

Fuzzified Performance Assessment

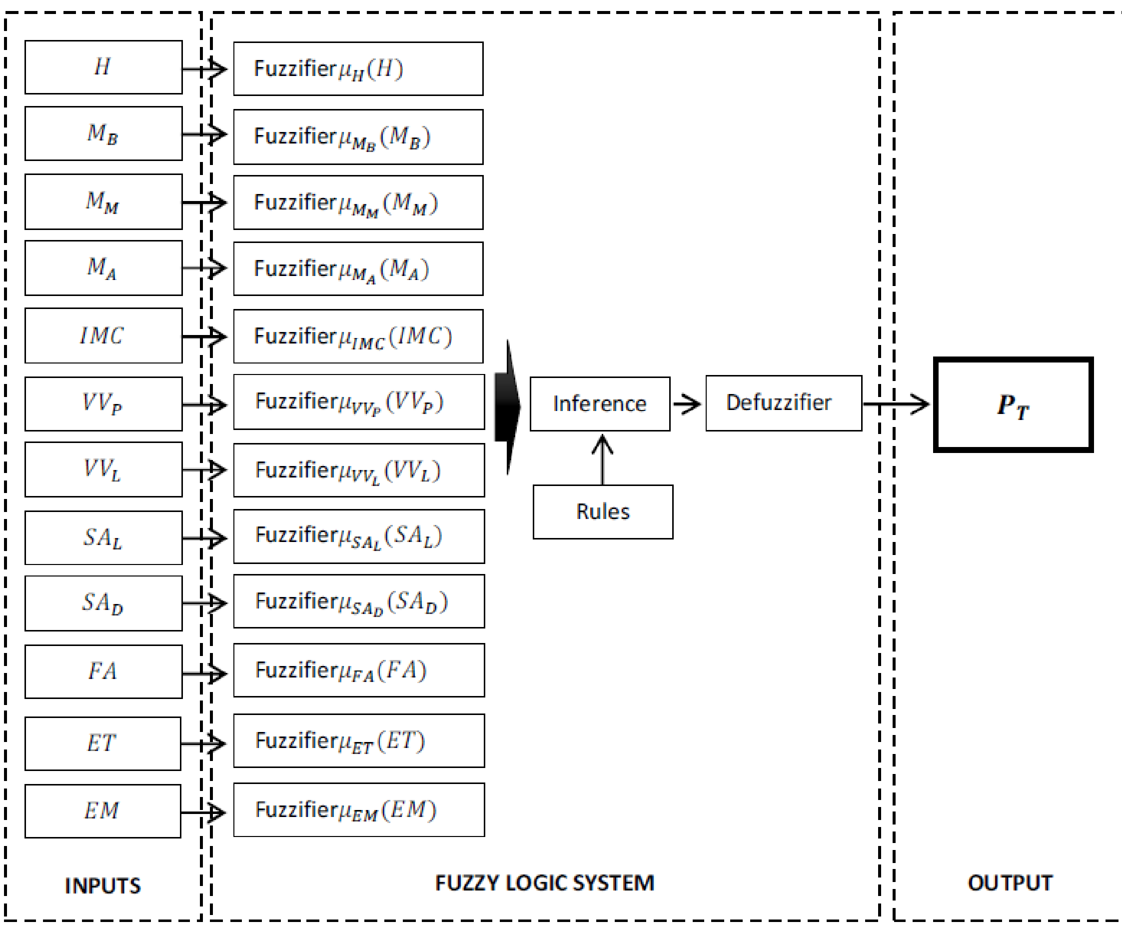
This work considers the use of a fuzzy logic architecture to estimate the score of each athlete by combining several inputs, namely from bioimpedance nature, and retrieved from the fitnessgram tests.
The literature shows that Fuzzy logic was introduced in 1965 by Zadeh (1965) at the University of California, Berkeley, to deal with and represent uncertainties. Despite the several possible approaches to implementing an online auto-tuning system, fuzzy logic seems to be the most fitted multiple criteria analysis tool (Couceiro et al., 2012). The key advantage of fuzzy logic over the alternatives is that uncertainty can be included into the decision process. Vagueness and imprecision, associated with qualitative data, can be represented in a logical way using linguistic variables and overlapping membership functions in the uncertain range (Couceiro et al., 2014).

This model is useful in the analysis of variables arising in this study, as it allows to correlate both physiological and performance indicators of sailors during the regatta. In this context, we considered the following inputs: 1) Height (cm) [H]; 2) Body mass (kg) [M_BM_B]; 3) % Lean mass [M_MM_M]; 4) % Fat mass [M_A]; 5) IMC [IMCIMC]; 6) Aerobic capacity Yo-Yo (number of paths) [VV_PVV_P]; 7) Aerobic capacity Yo-Yo (level) [VV_LVV_L]; 8) Back-saver sit and reach left (repetitions) [SA_LSA_L]; 9) Back-saver sit and reach right

(repetitions) [SA_DSA_D]; 10) Curl up (repetitions) [FAFA]; 11) Trunk lift (cm) [ETET]; and 12) 90º push up (repetitions) [EMEM]. All those lead to the following output: normalized total score [P_TP_T].
In a similar way to other approaches used in robotics, such as Couceiro et al. (2012) and Santos et al. (2015), the proposed Fuzzy Logic System is used to assess the normalized total score based on bioimpedance and fitnessgram variables (Figure 1).

By finding the most appropriate membership functions, which translate every input variable into a single estimated output with a high correlation with the real result, one may be able to estimate new incoming results by just considering the bioimpedance and fitnessgram variables. The fuzzifiers that yield the maximum pairwise Pearson's correlation coefficient between the fuzzy logic system output P_T and the real total score P_T^r may be found by considering the data retrieved from the 10 sailors included in this study. The optimization method considered to find the fuzzifiers' parameters is the Fractional Order Darwinian Particle Swarm Optimization (*FODPSO*) previously proposed (Couceiro et al., 2012).

Figure 1. Fuzzy logic architecture proposed to estimate the normalized total score based on the bioimpedance and fitnessgram variables studied during the regatta.



ISSN: 2326-6333

Fuzzifiers

All membership functions will be represented by a typical first order Gaussian function, for a generic X input variable, as (Zadeh, 1965):

$$\mu_X(X) = a_X e^{-\left(\frac{X-b_X}{c_X}\right)^2} \quad \text{(Eq 1)}$$

In that sense, parameters a_X, b_X and c_X will be optimized using the *FODPSO* algorithm until the following equation is ensured:

$$\max \rho_{P_T(a_X,b_X,c_X)P_T^r} = \max\left[\frac{cov\left(\rho_{P_T(a_X,b_X,c_X)P_T^r}\right)}{\sigma_{P_T(a_X,b_X,c_X)}\sigma_{P_T^r}}\right] \text{(Eq 2)}$$

Wherein $\rho_{P_T(a_X,b_X,c_X)P_T^r}$ is Pearson's correlation between the fuzzy logic system output P_T and the real total score P_T^r, and cov and σ represent the covariance and standard deviation, respectively (Cohen et al., 2013). It is worth noting that the fuzzy logic system output P_T depends on parameters a_X, b_X and c_X for each of the above inputs. In other words, this is an optimization problem with 36 dimensions (i.e., 3 parameters for each of the 12 inputs previously described).

To maintain the simplicity of the proposed approach, the fuzzy logic system will comprise a set of rules, where each of the input fuzzifiers directly relates with the output without any connective. Additionally, the OR connective of the complement of each input fuzzifier is considered (Zadeh, 1965). The defuzzification then considers all the elements using the Center-of-Gravity method (Shaw, 1998).

Data analysis

For data analysis, we used the average as a measure of central tendency, the standard deviation as a measure of absolute dispersion, and the coefficient of variation (CV) as a measure of relative dispersion. Aiming to analyse the potential linear bivariate associations between quantitative variables of the study, we used the Pearson correlation coefficient (r) for a 5% significance level. To this end, there was a normal distribution for all variables in the Shapiro-Wilk test, except for the Trunk lift test. In this variable, we used the Spearman coefficient.

Regarding the magnitude of the coefficients found, we chose the Pestana and Gageiro classification (2005), which states that: 1) values inferior to 0.20 indicate very low linear associations; 2) values between 0.20 and 0.39 indicate low linear associations; 3) values between 0.4 and 0.69 are considered moderate; 4) values between 0.7 and 0.89 are considered as highly associated; and 5) values between 0.9 and 1 indicate very high associations. A statistical analysis was performed using IBM SPSS Statistics software (v. 20, Chicago, IL), applying an alpha level of 0.05.

RESULTS

The results indicate that Optimist sailors exhibit an average height of 153.60±8.49 cm and an average body mass of 44.35±9.30 Kg. With the first morphological variable, CV, one can observe a homogeneous view of the variables (CV ≈ 7%), though the same does not hold for the body mass, where CV ≈ 21% (Table 1).

With regard to physical fitness variables, the sailors had substantially higher values of CV on the back-saver sit and reach test (i.e., left side) and 90º push up. In the remaining tests, the variation observed in the young sailors was substantially lower.

Table 2 shows the results of the sailors' physical fitness.

ISSN: 2326-6333

Table 1. Mean, standard deviation and coefficient of variation of significant predictors.

Predictor	Mean	*SD*	*CV*
Height (cm)	153.60	8.49	0.06
Body mass (kg)	44.35	9.30	0.21
Curl up (repetitions)	59.50	16.10	0.27
Back-saver sit and reach right (cm)	24.40	4.54	0.19
Back-saver sit and reach left (cm)	21.25	6.67	0.31
Trunk lift (cm)	29.30	1.64	0.06
90º push up (repetitions)	19.20	6.20	0.32
Aerobic capacity (m)	50.80	12.38	0.24

Table 2. Results of sailors' physical fitness tests.

Sailors n=10	Yo-Yo IR1		Back-saves sit and reach		Curl up	90º Push up	Trunk lift
	Pathways	Level	Left (cm)	Right (cm)	(Repetitions)	(Pathways)	(cm)
1	44	6	25.0	23.5	51	11	30
2	61	7	22.0	30.0	75	19	25
3	60	7	19.0	20.0	38	16	30
4	51	6	23.0	26.0	35	16	28
5	51	6	8.0	21.0	45	18	30
6	55	7	28.0	29.0	75	51	30
7	51	6	27.0	27.0	75	32	30
8	42	6	20.0	24.0	62	22	30
9	24	4	28.0	28.0	64	13	30
10	69	8	28.0	15.5	75	26	30

The data indicate that sailor 10 performed more pathways in aerobic capacity (Yo-Yo IR1), with a total of 69 pathways, corresponding to the Level 8 of this test. For the remaining physical components, sailor 6 was the one that had better results in the back-saver sit and reach test, i.e., 28.0 cm to the left and 29.0 cm to the right.

On the curl up test, sailor 6 performed 75 repetitions, reaching the maximum level of this test. Regarding the 90º push up test, the same sailor performed 51 repetitions. Finally, as regards to the trunk lift test, nearly all sailors met the 30.0 cm maximum, defined in this test, except sailor 2 (25.0 cm) and sailor 4 (28.0 cm).

Table 3 shows the ranking assessment of intra-individual performance in the six starts in sailing regattas.

Based on the scores achieved by sailors at the start of the sailing regatta, it is confirmed that the athlete who had the best performance was sailor 5, with 42 points, followed by sailor 2, with 41 points and, thirdly, sailor 3, with 40 points. Sailor 10, with 32 points, achieved the worst performance.

The results also indicate a linear, moderate and positive linear relation between body mass and the sailing performance (Table 4), where heavier sailors perform generally better in the regattas they took part in.

Table 3. Ranking assessment of intra-individual performance in the six starts of the sailing regattas.

Sailors'	Score	% Score	Ranking
1	39	72.2	4
2	41	75.9	2
3	40	74.1	3
4	35	64.8	6
5	42	77.8	1
6	35	64.8	6
7	37	68.5	5
8	37	68.5	5
9	40	74.1	3
10	32	59.3	7

Table 4. Relationship of physical fitness and the anthropometry profile with the sailing performance.

Predictor	Sailing performance
Height (m)	0.495
Body mass (kg)	0.718*
Curl up (repetitions)	-0.302
Back-saver sit and reach right(cm)	0.258
Back-saver sit and reach left (cm)	-0.209
Trunk lift (cm)	-0.082
90º push up (repetitions)	-0.447
Aerobic capacity (m)	-0.354

*Significant correlation to p-value=0.05; *Significant correlation to p-value=0.01

The remaining relationship established between performance and other variables revealed no statistical significance.

Going a step further in the analysis of the results, the fuzzyfied approach previously presented was adopted. To that end, the fuzzy logic architecture presented in Figure 1 was evaluated for every-single input, and equation 2 was optimized by stochastically find the best set of parameters a, *b* and *c* from equation 1 for each input variable. The *FODPSO* method returned a correlation coefficient of $\rho_{P_T(a_X,b_X,c_X)P_T^r} = 0.9525$ for the following set of parameters (Table 5).

Parameters a, b and c presented in Table 5 yield the following relationships, which illustrate the input membership functions found by the proposed fuzzy method (Figure 2).

Table 5. Set of parameters of equation (1) for each input variable.

	a	b	c
$\mu_H(H)$	120.99	124.97	-164.71
$\mu_{M_B}(M_B)$	12.19	-25.96	51.49
$\mu_{M_M}(M_M)$	-48.97	41.52	1.71
$\mu_{M_A}(M_A)$	-6.54	113.36	140.13
$\mu_{IMC}(IMC)$	-5.62	34.96	-61.16
$\mu_{VV_P}(VV_P)$	18.42	-109.14	-93.87
$\mu_{VV_L}(VV_L)$	-22.55	25.05	-126.59
$\mu_{SA_L}(SA_L)$	-77.70	75.80	39.59
$\mu_{SA_D}(SA_D)$	25.64	-26.01	-18.22
$\mu_{FA}(FA)$	30.45	-127.80	-99.14
$\mu_{ET}(ET)$	74.86	86.51	-110.60
$\mu_{EM}(EM)$	-82.54	-18.93	20.53

Figure 2a. Membership function for each input of the proposed fuzzy logic architecture

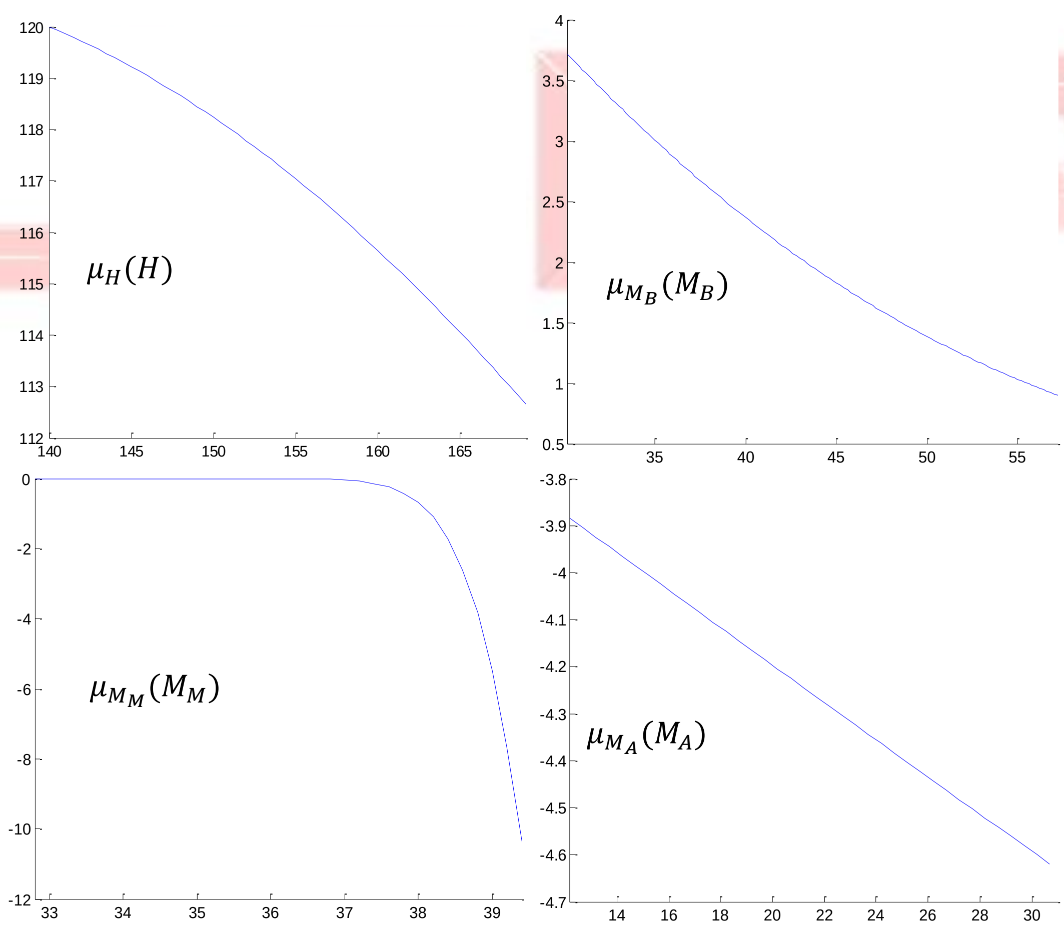


Figure 2b. Membership function for each input of the proposed fuzzy logic architecture

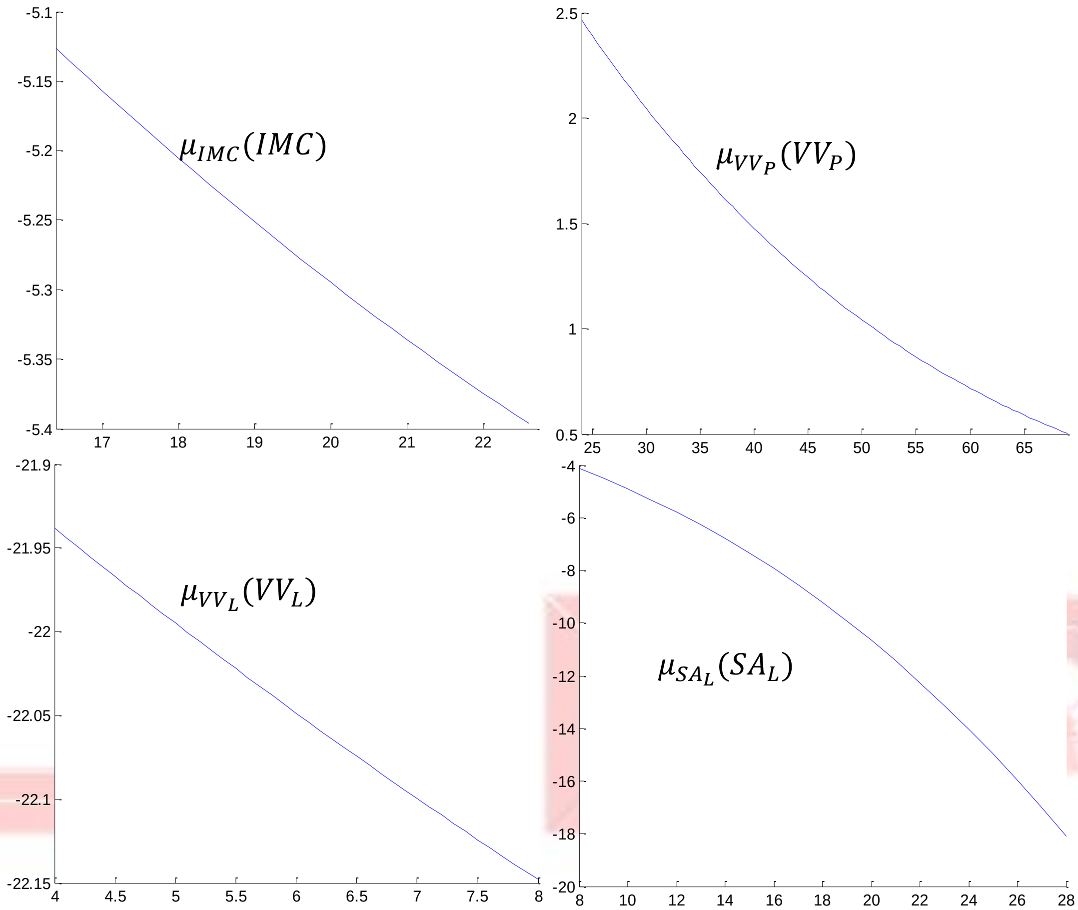
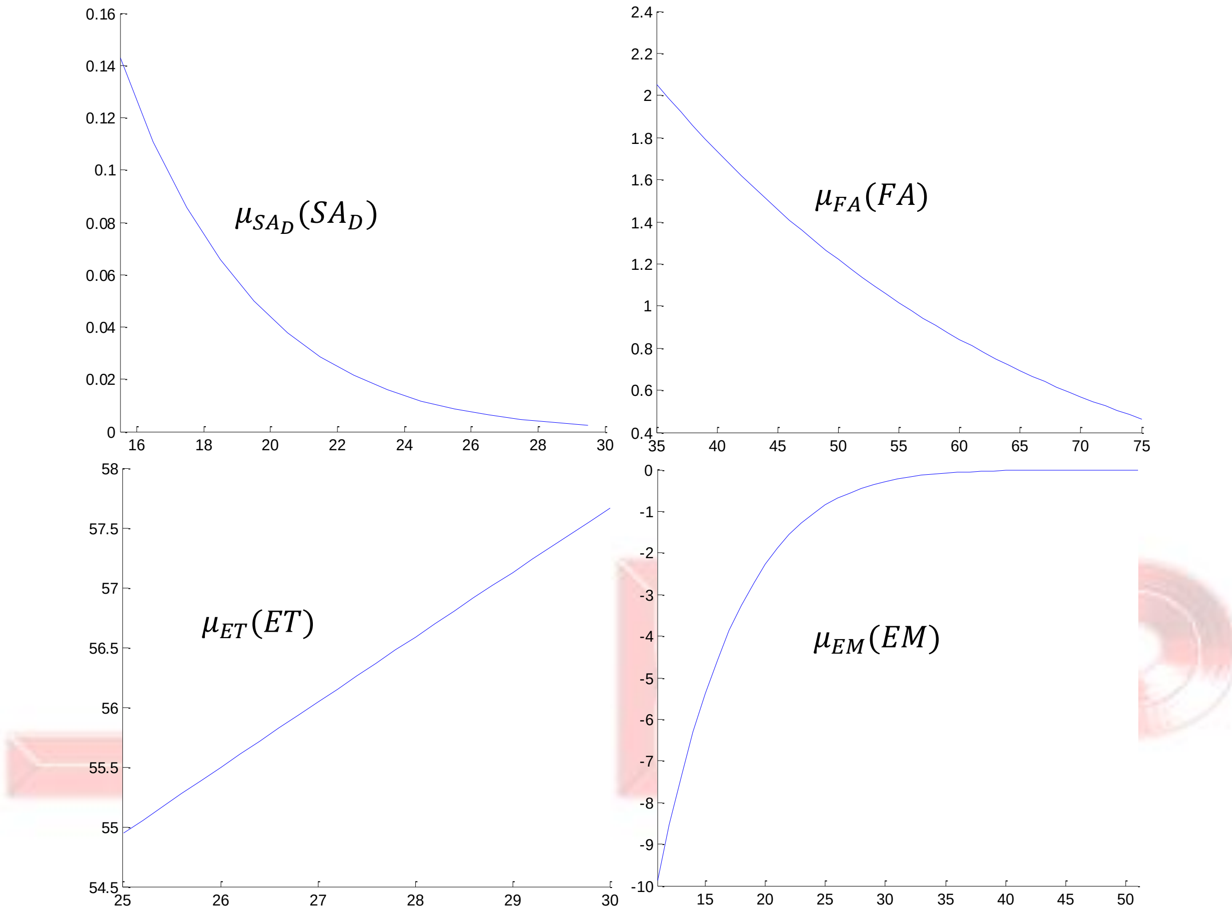


Figure 2c. Membership function for each input of the proposed fuzzy logic architecture



Note that the range of the inputs is defined by the sample of the ten athletes considered. Hence, sailors with variables of bioimpedance or fitnessgram nature outside this range may not be successfully evaluated.

As it can be observed, the relevance, or dependency, of the final score over the input variables is completely different. For instance, while the height H of the athlete presents the highest magnitude when compared to the other inputs, the membership function relative range (in proportion to the input variable) is considerably smaller when compared to other cases, such as the muscular mass M_M. On the other hand, some variables seem to have little to no relevance at all, as the $SA_D SA_D$, in which a variability between 15.5 and 29 as input yields a variability between 0.14 and 0 as output $\mu_{SA_D}(SA_D)$. Interestingly, one may also observe that, although most variables present an inverse relationship with the predicted total score, *ET* and *EM* are the exception to this rule. In other words, as the number of extensions increase, the score also tends to increase.

This fuzzy evaluation yielded a given normalized total score (in percentage) shown in the next table, side-by-side with the real total score (in percentage, Table 6).

Table 6. Estimated and real scores obtained for each sailor, sorted by rank. The coloured cells depict the misclassification, in which 4 out of 10 athletes were not adequately ranked by the fuzzy logic architecture.

Estimated score		*Real score*	
P_T[%]	*Athlete*	P_T^r[%]	*Athlete*
22.12	5	77.8	5
19.66	2	75.9	2
17.06	3	74.1	3
16.7	9	74.1	9
16.67	1	72.2	1
15.26	8	68.5	7
12.53	6	68.5	8
12.42	7	64.8	4
9.07	4	64.8	6
8.29	10	59.3	10

Despite the differences in the absolute values depicted by P_T and P_T^r, the ranking is generally maintained, with the fifth sailor leading the rank and the tenth athlete at the bottom of it. The method fails to estimate when sailors present almost the same score. For instance, although sailors 3 and 9 present the same real score (74.10), sailor 3 (17.06) is estimated as having a slightly better performance than athlete 9 (16.70) using the proposed fuzzy approach.

DISCUSSION

In general, the results showed poor correlations between physical characteristics and sailing performance. In this way, when Legg et al. (1997) examined the relationship between physical performance and racing performance, they did not identified any relationship between these variables, except that older sailors tended to have better racing performances. This finding indicates that sailors' experience may contribute the most to the sailing outcome. Furthermore, according to these authors (1997), factors, such as skill and talent, may have been the reasons for such poor relationships.

Despite these achievements, our data also indicate that the body mass is significantly related to sailing performance (Hadala et al., 2012). In fact, this variable is shown to be very important for the sailor to overcome the strong winds and the constraints faced during the performance. Sailing in high-winds requires great skill and physical effort to control the boat (Gore, 2000; Pulur, 2011). As sailing is a weight-supported and weigh-dependent, the body is used to provide leverage against the force of the wind to keep the boat stable and achieve higher speeds. In other words, heavier sailors tend to overcome more easily the constraints imposed by the wind and the ocean currents since their body weight can successfully oppose the inertia and the boat's motion under adverse conditions (Callewaert et al., 2014; Oliveira et al., 2011).

Therefore, it should also be noted that sailing teams select athletes with anthropometric dimensions more suited to perform the sailing manoeuvres to enhance their likelihood of competitive success (Hadala et al., 2012). Besides, Hadala et al. (2012) show that the overall body mass of athletes was larger in the last three America's

Cups, indicating a substantial increase in the lean body mass. For these authors, a common strategy of the teams has been to reduce the body fat of the whole crew to maximize lean muscle mass for the positions with the greatest strength and power requirements.

Given these arguments, Plyley et al. (1985) found that the body mass had a strong relationship with the sailing ranking for most of the Olympic classes of vessels, that flexibility gave a competitive advantage in the Soling class, and that hand grip strength helped in the Flying Dutchman class. In this context, Niinimaa et al. (1977) showed that, in high wind conditions, there was a competitive advantage for muscular strength tolerance of anaerobic effort and absolute aerobic power, as well as balance and resistance to mental fatigue. Moreover, Shephard (1997) has suggested that the aerobic power may serve as a marker for body mass, providing the ability to counterbalance the boat. Accordingly, our results indicated that the sailing intensity is influenced by the competitive similarity of the boats and the role of the athlete (Neville et al., 2009).

As demonstrated by our results, the body mass significantly influenced the performance of sailors, especially in situations where wind was moderate or strong, as was the case in our study (e.g., 2.9-13.0 knot, making an average by 7.7 knot). Moreover, it seems that heavier athletes tend to counteract different wind intensities better, adapting their performance to the boat manoeuvres (Legg et al., 1999, 2000, Neville, et al., 2009). Consequently, variable height and body mass may be regarded as very relevant for sailor 5 (156.0 cm and 52.2 kg) and sailor 2 (169.0 cm and 55.8 kg), who presented a better performance, being the heaviest and tallest athletes in the sample.

On the other hand, when we compared our results with recent studies that analysed the Optimist class (e.g., Medina, 2012, Serrano, 2013, Callewaert et al., 2014), it appears that the sailors who were part of the sample of these studies were, on average, lighter and shorter, which is presumably related to the fact that these athletes were younger than the ones in our study. The same can be stated for the percentage of fat mass, in which our data show higher values (18.32 ± 5.81 %) when compared to the six sailors (13.3 ± 4.0 %) analysed in the study of Callewaert et al. (2014).

In addition to the previously discussed factors**,** it seems that there is a need to understand the nature of the behaviours that emerge to seek information in adjusting the sailors underlying performance strategy (Araújo et al., 2006). Here, we show that ecological dynamics models imply that sailors' decisions can be viewed as emergent co-adaptive behaviours, based on other sailors and environment, and may be highly functional for achieving competitive goals (Araújo et al., 2014). Consequently, it is necessary to take into account the interactive effects between environmental and individual constraints that influence emergent performance in a sailing regatta (Pluijms et al., 2013, Araújo et al., 2014). This approach to sailing reveals how athletes perceive properties of performance environments as opportunities to act (i.e., affordances).

Therefore, the implication is that the ecological dynamics current understanding revolves around how the performance emerges from continuous interactions between sailors and constraints (Davids, 2015). From this perspective, the stability of functional co-ordination patterns can be altered by the imposed constraints (Araújo & Davids, 2009).

These approaches, which also result in the fuzzy model considered in this study, suggest that the adaptive behaviour emerges from this confluence of constraints under the boundary conditions of a particular context (Davids, 2015). In this sense, the data suggests that the successful development of a fuzzy architecture to model the behaviour of sailors is a complex multi-step process, in which the designer is faced with a large number of alternatives. As one may observe in the results, the relevance, or dependency, of the final score over the input variables is completely different. Despite the differences in the absolute values depicted by P_T and P_T^r, the ranking is generally kept, with the fifth athlete leading the table and the tenth athlete at the bottom of it. Such an approach is extremely useful to measure the performance fluctuations and irregularities of both novices and experts, as well as to assess their individual motor skill characteristics and profile (Couceiro et al., 2014).

On the other hand, these results demonstrated that fuzzy logic may be used to represent an alternative way of assessing performance analysis in sailing, taking into account multiple evaluation criteria. Yet, even when using an optimization method as presented in this paper, an expert knowledge about the task is still required in order to validate the rules and membership functions, thus providing a more reliable result. Therefore, fuzzy systems need expert experience to strengthen the decision rules and to handle imprecise values in its reasoning (Couceiro et al., 2014).

Given the above, Araújo et al. (2014) show that sailing performance can be understood as an integral part of goal-directed behaviour, which is influenced by bodily constraints at the level of the environment-athlete relationship. From this point of view, such flexibility is tailored to the demands of the current environmental conditions, and implicates an ongoing and systematic perceptual regulation of action principles (Araújo et al., 2006). To counter the forces of the wind, the sailors must lean out over the windward side of the boat. This activity involves quasi-isometric action of the muscles in the anterior side of the body (e.g., abdominals, hip and knee extensors especially) and requires strength, endurance and flexibility during racing (Steffen et al., 1999, Mackie et al., 1999).

To sum it up, our data are in line with Steffen et al. (1999), where poor correlations between physical and racing performances were observed in all classes for all of the sailing regattas. We concluded that the physical performance was poorly related to racing performance. This is understandable since the racing were fulfilled during light wind conditions where racing is not that physically demanding (Steffen et al., 1999). As such**,** our study reinforces the need for a better understanding of the morphological and functional variables of the sailors (e.g., flexibility, skinfolds, body weight, aerobic endurance, strength and muscle strength) in harmony with the environmental variables**.** These findings suggest that these variables are concomitants and cannot be separated or studied in isolation, but have to be analysed as a whole.

ACKNOWLEDGEMENTS

This research was supported by the Portuguese Foundation for Science and Technology (FCT) under the grant SFRH/BPD/99655/2014, Ingeniarius, Ltd., CIPER, Faculty of Human Kinetics, Technical University of Lisbon, Laboratory of Expertise in Sport (SpertLab), and Centre for Sports Engineering Research (CSER).

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