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Comparison of Manikin Carry Performance by Lifeguards and Lifesavers When Using Barefoot, Flexible and Fiber Fins

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The use of fins is fundamental in aquatic sport and saving rescue activities, large variety of models existing in the market. The main purpose of this study was to compare two groups (lifeguards and lifesavers) performing a manikin carry effort using barefoot, flexible and fibre fins. Ten licensed lifeguards and ten lifesavers performed 3 x 25 m with barefoot, flexible and fibre fins in manikin carry connected to a cable speedometer that measured instantaneous velocity (v). For lifesavers, fibre fins allowed higher v values compared with flexible fins. No differences between fins models were observed regarding v of lifeguards. Additionally, the use of flexible or fibre fins do not show differences in fatigue index for both groups.

Key words: Biomechanics, lifesaving, rescue, fatigue

INTRODUCTION

The use of fins is fundamental in some professional and sport aquatic activities (e.g. diving, underwater fishing, sea rescuing, fin swimming, underwater hockey and sportive diving). Aquatic rescue considers both professional and sportive events, in which lifeguards and lifesavers are being involved, respectively. The purpose of each group is different: lifeguards are required to rescue a person for saving his/her life and don't compete; lifesavers are asked to achieve a best performance against the stopwatch and don't save real persons. Fins are a fundamental element for both lifesavers and lifeguards, besides lifesavers don't use fin in every events. Besides the difference in purposes, to choose the best fin model is a common concern of lifesavers and lifeguards.

Fins can be classified in two major types: mono and single fins. Each type presents a large variety of models, being distinguished by their stiffness, surface (width and length), flexibility and composition. Although monofins allow higher velocities when compared to single fins (Zamparo et al., 2006), they could not be used for lifesaving purposes, since they do not allow walking in a real rescue situation.

There are a limited number of studies on single fins efficacy. Nevertheless, some physiological parameters were studied by Daniel and Klauck (1992). Authors found that lactate accumulation and heart rate trends in life-saving are comparable to those produced by competitive swimmers. Economy and efficiency were assessed by Zamparo et al. (2006), that found that large and heavy fins were characterized by approximately the same economy and efficiency of fins with smaller surface but better buoyancy. Carrying by chest or head techniques were characterized by Juntunen et al. (2006), and the velocity in aquatic rescues was assessed by Abraldes et al. (2007). Last ones showed that velocity was higher when fins were used, independently of the fin type.

Considering the large variety of fin models available, it is important to understand which is the best fin model fitting the needs of both lifesavers and lifeguards. Some studies were conducted in this topic, but in different populations, analysing swimming or mannequin-carry events using different effort distances (Abraldes et al., 2007), but lifeguards and lifesavers were never compared. Specialized literature leads to think that the best fin model is not necessarily the same for different populations but studies results are not homogeneous. In carry efforts related studies, results were different from those above. In fact, although differences were not found between different fin models in 25 m mannequin carry effort (Abraldes, 2004), in another study with a similar sample, Abraldes (2005) found best carry performances when stiff fins were used, comparatively with flexible, short and fibre fins. Additionally, for 50 m carry performed by university students, Abraldes (2006) found that the use of stiff fins allows higher performances comparatively with flexible fins, but only in the first 25 m of the effort. Contradictory findings could probably be related with differences in subjects' number and characteristics. Lastly, Abraldes et al. (2007) analyzed carry velocity with barefoot, flexible and fibre fins obtained by lifeguards. Authors observed that fibre fins can provide a steadier velocity during a short sprint, comparatively with flexible fins.

Since it was never tried to compare lifesavers and lifeguards concerning fin models, the main purpose of this study was to compare these two groups performing a manikin carry effort using barefoot, flexible and fibre fins. Complementarily, it was aimed to study fatigue in carry, since literature is scarce about this subject.

METHODS

Twenty subjects, 10 licensed lifeguards and 10 lifesavers, were tested. The main physical characteristics of the subjects are described in Table 1.

Table 1. Mean ± SD values of the subjects main physical characteristics.

Subjects	Age (years)	Weight (kg)	High (cm)	BMI ($kg.m^{-2}$)
Lifesavers (n=10)	17.08±2.24	72.90±11.71	176.43±3.96	23.37±3.33
Lifeguards (n=10)	27.44±10.79	76.22±11.92	179.33±7.45	23.56±2.14

All tests were performed in a short course (25 m) indoor swimming pool with a mean depth of 2 m. The protocol consisted of a 3 x 25 m maximal swim trials carrying a manikin (Swedish model), with a minimum recovery time of 30 min. The manikin was constructed with a closed PITET plastic type, had a total height of 1 m and was totally filled of water in order to have a total land weight of 80 kg. The trials' order was randomized, performing with barefoot, with flexible fins (Gabbiano Francis, 45 cm length and 20 cm width, with a closed shoe part and a small opening for the toes fingers), and with fibre fins (Special Films, model Sebak Saber 140 Hard M, 65 cm length and 22 cm width, being rectangular on is tail, with a open shoe part on the heel and fixed to the lifeguard foot by a brace).

Each 25 m bout started within the water, with the subjects in contact with the wall or the starting block, head in emersion and carrying the mannequin (lateral-dorsal position). Subjects could kicking and use one arm for propulsion. A cable speedometer (Lima et al., 2006), was connected to the mannequin in order to obtain instantaneous velocity (v) during total event. The cable speedometer uses an incremental sensor with 500 points resolution per revolution. A brake engine allows the full system inertia to be insignificant, keeping the line always stretched. Accuracy and reliability of the speedometer was confirmed by Lima (2006). During the data analysis, the first two s the v curves of each swimmer were removed, minimizing the effect of the initial impulse, and focused the analysis on leg kicking only (there were no propulsive actions with the arms). The v were assessed over 2 s periods (Fig. 1), on three moments of the total v curve: (i) mean v correspondent to the initial 2-4 s of the total effort time; (ii) mean v correspondent to the middle part of total effort time and (iii) mean v correspondent to the last 2 s of total effort time. Total effort time was defined as the time duration between the first and the last v peak of the v(t) curve, after initial impulse has been removed.

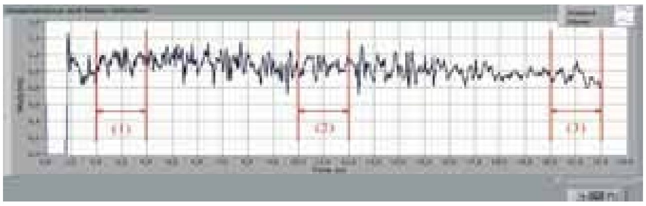

Figure 1. Instantaneous velocity curve obtained using the velocymetric system and time intervals (segments) used to calculate mean initial (1), middle (2) and final (3) velocities.

The mean slopes corresponding to the individual regression lines plotted between initial and middle v, between middle and final v and between initial and final v were calculated for both groups. The mean fatigue indexes (FI) corresponding to the first and second middle and to the total effort time were also assessed according to the following formula:

$$F = (\overline{X}i - \overline{X}f)\,\overline{X}i^{-1}, \qquad (1)$$

where $\overline{X}i$ is the mean v computed during 2 s in the beginning of each part of the test (the total test distance or each middle part considered) and $\overline{X}f$ is the mean v computed during 2 s in the end of the respective distance. Formula 1 has already been used by Soares (2006). Mean v, slope of the v(t) decline (v decay) and FI in the first and second middle parts of each 25 m, and in the total test, were used as fatigue criterions to study the fatigue induced during the total effort time, and during each middle parts, considering the three conditions tested.

The normality (Shapiro-Wilk test), sphericity (Mauchly Test) and homocedasticity of all distributions were confirmed. A paired simple T-test was used to compare vmean, slopes and FI corresponding to the first and second middle of the total effort time. T-Test was used for comparisons between lifesavers and lifeguards too. Tests were performed for each group. Repeated measures ANOVA have been applied to test differences between the three tested conditions. Significance was accepted at 0.05.

RESULTS

The v attained in the initial, middle and final moments of the 25 m carry effort can be observed in Table 2. Lifesavers performed faster than lifeguards in all three segments when using fibre fins. Carry velocity with flexible or fibre fins seemed to be indifferent for lifeguards. Lifesavers and lifeguards performed slower in the barefoot condition in any segment of the 25 m effort.

Table 2. Mean ± SD values of the velocity ($m \cdot s^{-1}$) corresponding to initial, middle and final segments of the total carry effort performed with barefoot, flexible and fibre fins by lifesavers and lifeguards.

	Initial		Middle		Final	
	Lifesavers	Lifeguards	Lifesavers	Lifeguards	Lifesavers	Lifeguards
Barefoot	$0.77\pm0.08^{*}$	0.67 ± 0.06	0.71 ± 0.09	0.66 ± 0.07	$0.61\pm0.11^{¤}$	$0.57\pm0.10^{¤}$
Flexible	1.12 ± 0.12^{a}	1.03 ± 0.10^{a}	1.09 ± 0.11^{a}	0.98 ± 0.20^{a}	0.99 ± 0.10^{a}	0.93 ± 0.12^{a}
Fibre	$1.31\pm0.11^{*ab}$	1.09 ± 0.12^{a}	$1.33\pm0.09^{*ab}$	1.07 ± 0.19^{a}	$1.21\pm0.11^{*ab}$	1.01 ± 0.12^{a}

Differences (p≤0.05) between groups: *different from lifeguards;
Differences (p≤0.05) between conditions: adifferent from barefoot; bdifferent from flexible fins;
Differences (p≤0.05) within conditions: ¤different from initial velocity of the same group.

Figure 2 presents analysis related to each half effort part. As can be observed (panel A), there were no differences in the total carry time of lifesavers and lifeguards in any condition. In Figure 2 (panel B), it may be observed that the use of fibre fins allowed for lifesavers to perform faster (in each middle part and for the total effort) comparatively with flexible fins. On the contrary, lifeguards attained similar v mean with both fin models. In barefoot condition, only in the first middle effort part, the lifesavers attained higher v than lifeguards.

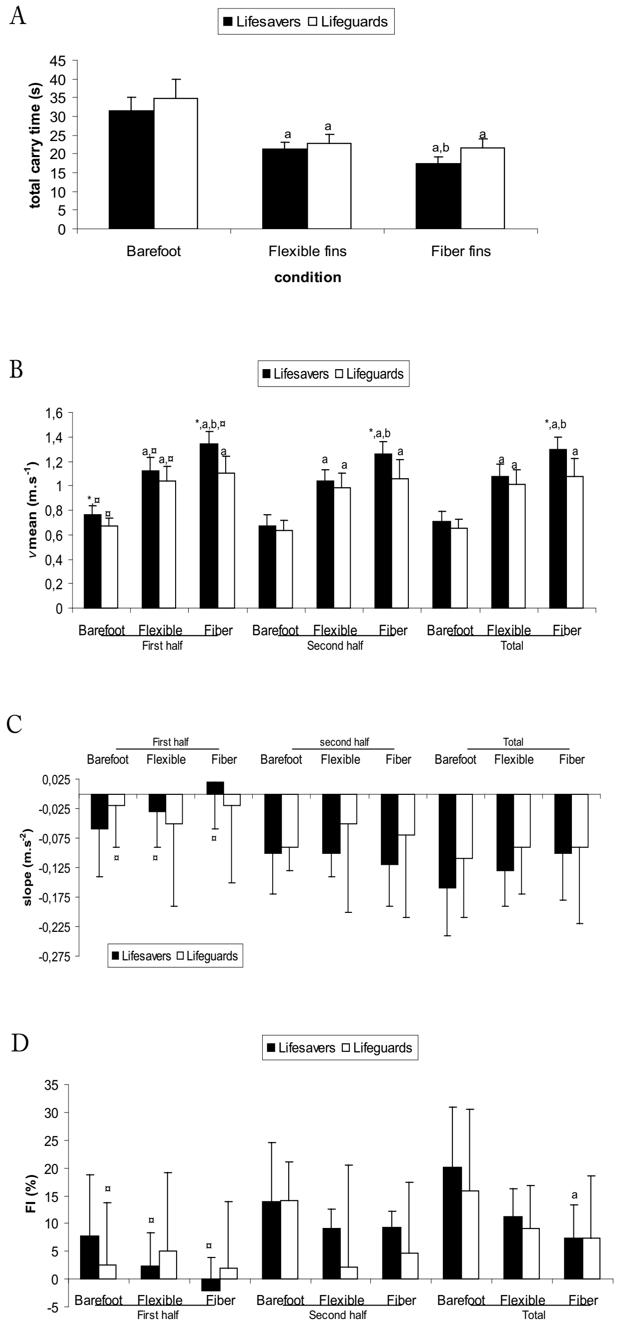

Figure 2. Mean ± SD values of lifesavers and lifeguards when carry with barefoot, flexible, and fibre fins. A: total duration of the mannequin carry effort (t); B: velocities (v_{mean}, $m \cdot s^{-1}$) of the first and second halves of the effort, and for the total effort; C: slopes of v(t) decline ($m \cdot s^{-2}$); D: fatigue indexes (FI, %).
Differences (p≤0.05) between groups: *different from lifeguards;
Differences (p≤0.05) between conditions: adifferent from barefoot; bdifferent from flexible fins;
Differences (p≤0.05) between half parts: ¤different from second middle part.

Figure 2 (C) shows that the use of fibre fins by the lifesavers implies the rise of the v and fatigue inhibition during the first middle effort part. The decline of lifesavers v does not appeared to be, in general, different from the results observed for lifeguards. Figure 2 (D) reveals that fatigue induced by carrying is similar for both studied groups and conditions, and that the use of fibre fins help lifesavers to delay fatigue in the first middle part of the effort. The differences in results are very similar to the slop results, with the same punctual differences being observed. Additionally, high SD values for FI are evident, showing a large individual variability among subjects.

DISCUSSION

Due to the high variability in fin models, a careful selection is required in order to increase performance or to facilitate rescue situations. As no study compared the performance obtained by lifesavers and lifeguards when using different fin models, the purpose of the study was to compare lifeguards and lifesavers when using flexible and fibre fins, which were compared also with the barefoot condition.

The observed higher v at the end of the 25m effort (final v) attained by lifesavers when using fibre fins could be due to the fact that they are commonly used in training and competition situations. Contrarily, fibre fins do not seem to be so often used in rescue situations, requiring lifeguards a more specific adaptation. This statement is only based on observation of the lifeguards' behaviour in rescue scenes. The initial, mean and final segments vmean of lifesavers and lifeguards in the 25 m mannequin carry test were similar when flexible fins were used. The inexistence of differences in v attained by lifeguards using four different fin models was already pointed out by Abraldes et al. (2007). It is possible that the eventual lower training level of lifeguards compared to lifesavers did not allow for a specialized use of any of the tested fin models. Other possible explanation is that lifesavers usually carry dummies in standard events, and lifeguards carry real persons in real and unexpected circumstances.

Additionally, it is speculated that lifesavers revealed a higher level of technical carrying competence at the beginning of the barefoot effort, once they got a higher initial vmean. This difference in vmean between lifesavers and lifeguards observed in barefoot condition was not evident in the middle and final moments of the test. Regarding fatigue related parameters, v decay and FI seem to be similar between lifesavers and lifeguards in the three conditions tested. This absence of differences could be a consequence of the short effort duration of the particular test used. Moreover, it can be explained by the inexact location of the point of exponential rise of fatigue. In the present study, the effort was divided in two parts, without the exact point of evident fatigue occurrence being determined. Future studies should focus on a more precise assessment of the point of fatigue appearance. Soares et al. (2006) have studied fatigue analysing velocity in 30 s maximal swimming efforts. The authors could determine one or two fatigue thresholds over the 30 s v(t) curves, none of which being coincident with the middle of the effort. Fatigue thresholds were above the 15 s.

Lastly, a noticeable result was the increase of vmean during the first middle carries performed by the lifesavers with the fibre fins, which favour its use by this population. Another highlight is the significant variability of FI data. The abnormally higher SD values could explain, in part, the absence of significant differences observed for FI, which suggests the need of further research.

CONCLUSIONS

Fibre fins allow a higher v of lifesavers when compared with flexible fins, but for lifeguards it is indifferent the type of fins used. The effect of the use of flexible or fibre fins is not evident in fatigue index both for lifesavers and lifeguards.

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