FORCE ANALYSIS OF THE UNDERWATER STATIONARY RUNNIG

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It aimed to analyze the vertical component of the ground reaction force in the underwater stationary running. The sample was composed by 6 subjects divided in two groups (Male Group and Female Group). The underwater stationary running was performed in two immersion levels: in the hip level and in the xiphoid process level. An underwater force plate was used. For data analysis descriptive statistics was used. The mean values of vertical GRF were 2,08BW for the MG and 1,69BW for the FG in the hip level; 1,15BW for the MG and 1,12BW for the FG in the xiphoid process level. The results showed the vertical component of the GRF is affected by the immersion level and by the frequency of the activity. Both factors should be considered by professionals who work with therapeutic or physical conditioning programs using the underwater stationary running.

KEY WORDS: Underwater running, aquatic rehabilitation, physical conditioning.

INTRODUCTION:

The aquatic exercise, as the stationary running, is used in treatment programs and/or physical conditioning for lots of people. The stationary running is a physical activity that is part of hydro gymnastics programs as an efficient conditioning way. Besides, the load relief in body joints characterizes this activity as indicated for rehabilitation, specially for those patients who present injuries in the muscle or skeletal systems, for whom the same activity performed over ground could be dangerous (Bates and Hanson, 1998; Becker and Cole, 2000; Campion, 2000; Ruoti, Morris and Cole, 2000).

Despite of popularity of this exercise, few biomechanical studies are found in literature, which makes difficult the performance of physiotherapists and physical educators involved with the health maintenance and rehabilitation. Thus, it is necessary to identify the variables related to the underwater stationary running. The studies found in literature analyzed physiological variables related to this activity (blood pressure, heart rate VO_2 max and body temperature); papers related to Physiotherapy in the water analyze injuries recuperation using aquatic exercises as a therapeutic resource. The lack of biomechanical studies in this area is also commented by other researchers (Harrison, Hillmann and Bulstrode, 1992; Yano, Nakazawa and Yamamoto, 1995; Yamamoto, Yano and Nakazawa, 1995; Schütz, Haupenthal and Roesler, 2005; Souza et al., 2005; Roesler et al., 2006; Barela, Stolf and Duarte, 2006).

The present study analyzed the vertical component of the ground reaction force (GRF) in the underwater stationary running.

METHOD:

Data Collection: The sample was composed by 6 subjects, divided in two groups according to the gender: male group (MG) and female group (FG). Each group was composed by 3 subjects. The subjects were deliberately chosen by agreeing to the terms of the study, according to enclosure criteria: no gait disorders; height of 1,80±0,02m for the male group and 1,60±0,02m for the female group; and older than 18 years (the mean of age was 22±3 years old).

Data collection procedures began with the measuring of anthropometric data as follows: (a) body mass of the subjects using an electronic scale (Plenna, model MEA-08128, 0,1Kg scale); and (b) subjects height, using a metric tape.

In order to obtain the vertical component of GRF (Fy) an underwater force plate (Roesler, 1997; dimensions 500mm x 500mm x 200mm, sensitivity of 2N, error lower than 1% and 60Hz of native frequency) was used, with a sample frequency of 600Hz. The system for the

acquisition of dynamometric data was completed by a 16 channels CIO-EXP-BRIDGE board and by the CIOD-DAS-16Jr A/D converter. For signal analysis and editing SAD 32 system 3.0 (Silva and Zaro, 1997) was used.
The force plate was placed at the bottom of a thermal swimming pool (30±1°C). Two immersion depth were used: (1) hip level of the subjects (1,00m for MG and 0,90m for FG); and (2) xiphoid process level of the subjects (1,25m for MG and 1,15m for FG). After the anthropometrical measurements the subjects were asked to enter in the pool. Each subject had an adaptation period in order to get used to equipment and data collection conditions.
Data Analysis: The force curves were analyzed through the following steps: (1) application of the calibration coefficient and filters (FFT Butterworth filter, low-pass cut-off frequency of 30Hz, order 3); (2) normalization by the body weight (BW) measured outside the water (in order to observe the percentage of reduction of the force values in comparison with the values outside the water); (3) verification of the maximum value of the vertical force for each curve, named force peak; (4) verification of contact time in each support condition; (5) curve normalization by the support percentage; (6) calculation of the mean curves; and (7) verification of the mean values for the vertical component of GRF.
The exercise intensity was obtained by Fast Fourier Transformed (FFT) of the curves, which provided the frequency of the underwater stationary running.
For data analysis, descriptive statistics (mean, standard deviation and coefficient of variation) was used.

RESULTS:

The total number of analyzed force curves was 240 (20 curves of each subject in each immersion depth). Figure 1 shows a MG subject performing the stationary running in the hip level (left) and a FG subject performing the activity in the xiphoid process level (right).

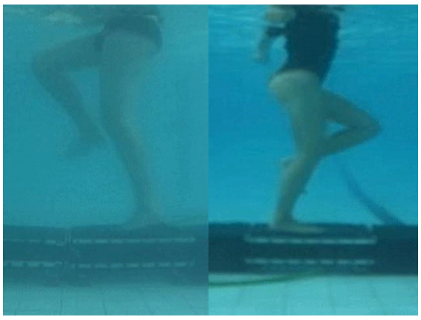

Figure 1 – Left: MG subject performing the stationary running in the hip level; Right: FG subject performing the stationary running in the xiphoid process level.

Table 1 shows the values of mean (m), standard deviation (sd) and coefficient of variation (cv) for the variables contact time, force peak and frequency of the underwater stationary running, for both male (MG) and female (FG) groups.

Table 1 – Values of mean (m), standard deviation (sd) and coefficient of variation (cv) for the variables contact time, force peak and frequency of the underwater stationary running.

		Hip level		Xiphoid process level	
		MG	**FG**	**MG**	**FG**
Contact time (s)	m	**0,27**	**0,31**	**0,30**	**0,28**
	sd	0,02	0,02	0,03	0,02
	cv	7,3%	6,6%	8,6%	7,0%
Force peak (BW)	m	**2,08**	**1,69**	**1,15**	**1,12**
	sd	0,15	0,15	0,11	0,10
	cv	7,1%	8,9%	10,3%	8,7%
Frequency (Hz)		**2,0**	**1,7**	**1,9**	**1,9**

* BW: body weight

Figure 2 shows the vertical component of the GRF curve. Notice the curve is normalized by the time support percentage and does not show temporal characteristics.

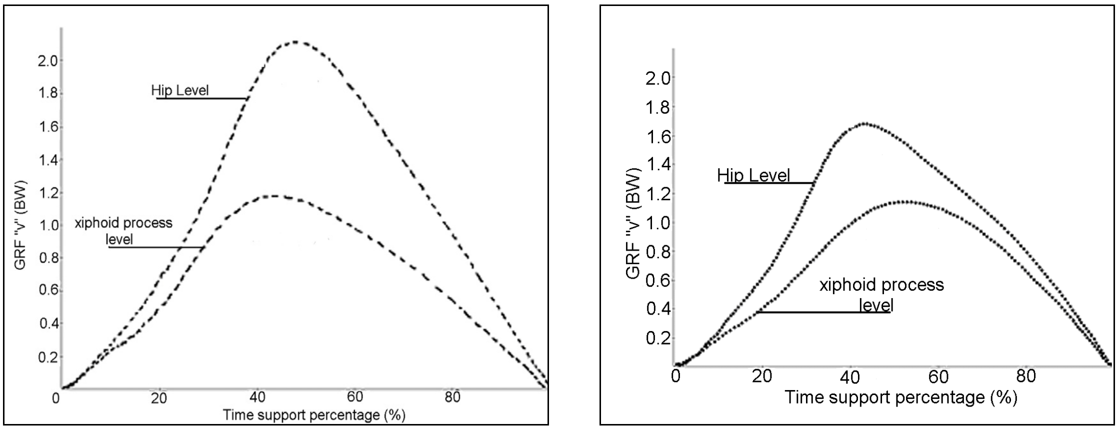

Figure 2 – Left: mean curve of the GRF vertical component for the male group; right: mean curve of the GRF vertical component for the female group.

DISCUSSION:

The results presented in Table 1 show that the vertical component of the GRF is affected by the immersion level. The same was observed by other researchers for the analysis of the underwater gait (Harrison, Hillmann and Bulstrode, 1992; Yamamoto, Yano and Nakazawa, 1995; Souza et al., 2005; Roesler et al., 2006). In this study, the mean value of the force peaks was 2,08BW for MG ad 1,69BW for FG when the subjects performed the stationary running in the hip level of immersion; and 1,15BW for MG and 1,12BW for FG when they performed the activity in the xiphoid process level of immersion. Comparing the two levels of immersion, values of force were almost twice higher in the hip level. Professionals believe the increase of force intensity is related to the decrease of the level of immersion and they currently use this alternative in treatment protocols and exercise programs. This situation is now proved by this dynamometric analysis.

Another way to control the intensity of the resultant force is to verify the frequency of steps during the exercise. Although this way of control is not frequently used, it can be as efficient as the immersion level control. The results of this study show that for the xiphoid process level of immersion the subjects performed the same frequency (1,9Hz) and the values of force peak were similar for both male and females groups (difference of 0,03BW). However for the hip level the frequency was different (2,0Hz for MG and 1,7Hz for FG) and also the values of force peak (difference of 0,39BW, almost ten times higher than in the xiphoid level). This difference is an important factor to consider during a therapeutic functional recovery and suggests the force peak is more influenced by the step frequency than by the gender.

The values of contact time were similar for both immersion levels and for both male and female groups (ranging from 0,27s to 0,31s), being inversely proportional to the step frequency.

Making an analogy with activities outside the water one could say that, considering the vertical component of GRF, a subject who is capable of walking in a normal speed could perform the underwater stationary running in the xiphoid process level of immersion, because the mean values of force peaks are similar, around 1,1BW (Roesler et al., 2006; Barela, Stolf and Duarte, 2006; Nigg and Herzog, 1994; Perry, 1992). However the contact time is smaller in the underwater stationary running and the subject suffers a great impact. And still, to perform the underwater stationary running, the subject needs good levels of mobility, cardiovascular conditioning and motor control, and also needs to be adapted to the aquatic environment. One made this analogy in order to facilitate the work of professionals who work with aquatic exercise prescription.

During a therapeutic process of rehabilitation one should not only care about the immersion level but also about the frequency of the stationary running, in order to know the load intensity the subject is submitted. Even with the immersion in the water, for example in the hip level, the subject performs the underwater stationary running in a 2,0Hz frequency, which can be more intense than his capacity and could damage the recovery process.

CONCLUSION:

This study presented the mean values of the vertical component of GRF during the underwater stationary running in hip and xiphoid process levels of immersion. The results show that this activity can be used as an efficient way of physical conditioning or therapeutic recovery process and the professionals should control, besides the immersion level, the step frequency. Data presented in this paper are going to facilitate the work of professionals involved with the prescription of aquatic activities.

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