29 - DETERMINATION OF SAMPLING RATE AND NUMBER OF EXECUTIONS FOR DATA COLLECTION IN UNDERWATER RUNNING ANALYSIS

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INTRODUCTION

Day after day the search for a physical activity increases in the population. Every year Hidrogymnastics has more adepts, especially elderly and overweight people, who use to present musculoskeletal discomfort after an impact activity (walking or running) and do not feel comfortable practicing exercises in land (TAKESHIMA *et al.*, 2000, PÖYHÖNEN *et al.,* 2001b, MASUMOTO *et al.,* 2004). But nowadays beyond these special populations, athletes are looking for hidrogymnastcis as a way of fitness training, of physical conditioning recovery between two competitive events and of rehabilitation (KANEDA *et al.,* 2007, DOWZER *et al.,* 2006, THEIN *et al.,* 1998).

Water exercises are also used to functional rehabilitation. In this process, the physiotherapist uses the reduction of resultant during running exercises in aquatic environment, anticipating this activity in the water and preparing the patient to carry out the same activity in land. To do that, the physiotherapist gradually decreases the immersion depth during the treatment, until the patient is able to carry out the activity on land (RUOTI, MORRIS and COLE, 2000, KUORI, 2000, CAMPION, 2000, BATES and HANSON, 1998).

Despite of popularity of aquatic exercises, there are not enough studies regarding biomechanical variables; thus it makes thing difficult for Physiotherapists and Physical Education professionals working with health maintenance and rehabilitation programs, who have to prescribe and orient this kind of exercise in their routines (BARELA *et al.,* 2006, ROESLER *et al.,* 2006). Some authors relate this lack of underwater GRF analysis to the need of a specific and adjusted instrument for this measurement and not to the disinterest of scientific community, especially because Physiotherapists and Physical Education professionals prescribe aquatic exercises every day (PÖYHÖNEN *et al.,* 2001, CAMPOS, 2001, DUARTE, 2001).

Thus the objective of this study was to determine the sampling rate, the filtering cut-off frequency and the number of executions for data collection of dynamic variables in underwater running.

METHOD

After the approval of Ethics Committee in Research of Santa Catarina State University (UDESC) the participant was informed, through an invitation letter elaborated by the researcher that explained all the procedures for data collection and has agreed to be part of the study. The subject was a 27-year-old man, 1,80m of height and 84,3kg of body mass.

All the tests were carried out in the swimming pool by the Aquatic Biomechanics Research Laboratory of the Center of Health and Sport Sciences of UDESC.

In order to obtain the vertical component of GRF (Fy) an underwater force plate (ROESLER, 1997; dimensions of 400mm x 400mm x 200mm, sensitivity of 2N, error lower than 1% and natural frequency of 300Hz) was used, sampled at 1000Hz. Acquisition system was completed by a 16- channel board (CIO-EXP-BRIDGE) and an A/D converter (CIOD-DAS-16Jr). Signal were acquired, analyzed and edited by SAD 32 system 3.0 (Silva and Zaro, 1997).

The force plate was placed at the bottom of a thermal swimming pool (30±1°C) between boxes that formed an 8-meter walkway. The boxes and the force plate were covered by an antiskid surface to prevent sliding during the underwater running. The walkway was placed according to subject's height (according to the anatomical structure of reference in each analyzed situation).

The subject had an adaptation period, in order to get used to the equipment and the data collection conditions. Two immersion levels were used: (1) subject's hip level and (2) subject's sternum level. After the anthropometrical measurements, the subject was asked to enter in the pool. These levels were used in order to facilitate exercise prescription in aquatic environment through the selection of a standard anatomical point that could be easily identified by the physical educator or the physiotherapist.

The subject performed 30 valid passages in his self-selected speed for each immersion level. The passage was considered valid when the subject touched the force plate without looking at it or changing the movement pace.

Data were exported and treated through Scilab software (INRIA). In this software two programming routines were created for data analysis. The first one carried out Fourier transform to provide the power spectral density analysis through the average of all transformed curves. The second routine extracted data as follows: (1) application of the calibration coefficient and filtering (low-pass filter FFT Butterworth type with a cutoff frequency of 20 Hz and order 3); (2) normalization by the body weight measured outside the water (in order to observe the relative reduction of the force values comparing to the values outside the water); (3) verification of the maximum force value for the vertical component of GRF (Fy); (4) verification of contact time during support phase; (5) curve normalization by the support percentage; and (6)calculation of Fy average curves.

Descriptive statistics (mean, standard deviation and coefficient of variation) was use to characterize data. In order to determine the number of executions, accumulated coefficient of variation was analyzed (MELO, 1995).

Since this number of execution was defined, data were divided in different groups regarding the number set as necessary for data analysis. Inferential statistics was carried through NOVA and Post Hoc through Tukey HSD ($p<0,05$).

RESULTS AND DISCUSSION

The total number of curves was 77 (34 curves in the sternum immersion level and 33 curves in the hip immersion level).

When analyzing the result of spectral density curve (Figure 1), it was observed that data could be collected with a sampling rate of 200 points per second, 10 times higher the signal frequency, which guarantees its integrity during acquisition. These results could also be used to set the filtering cut-off frequency of 20 Hz, once the original signal's frequency is lower than the cut-off frequency. It was also verified that signal intensity is higher for the hip level than for the sternum level, suggesting the hip level would present higher values of force.

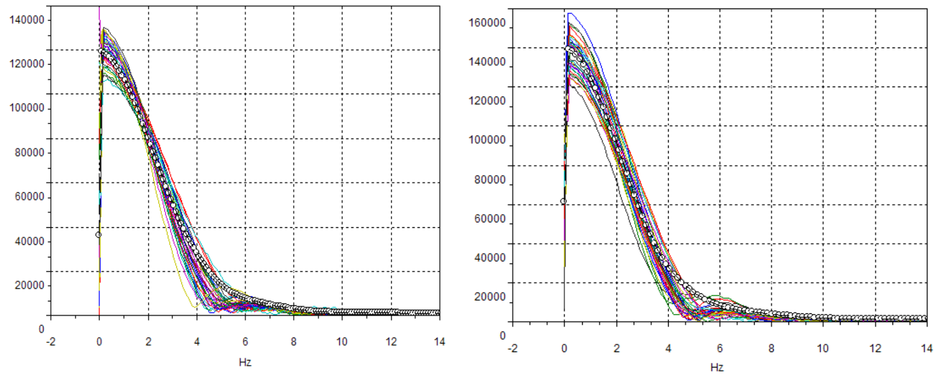

Figure 1 - Spectral density curve and Fourier transform in sternum immersion level (left) and hip immersion level (right) when performing the underwater running.

The force curves normalized by the body weight and by the period of support are presented in Figure 2. As expected, the force values in the hip level were higher than values in the sternum level.

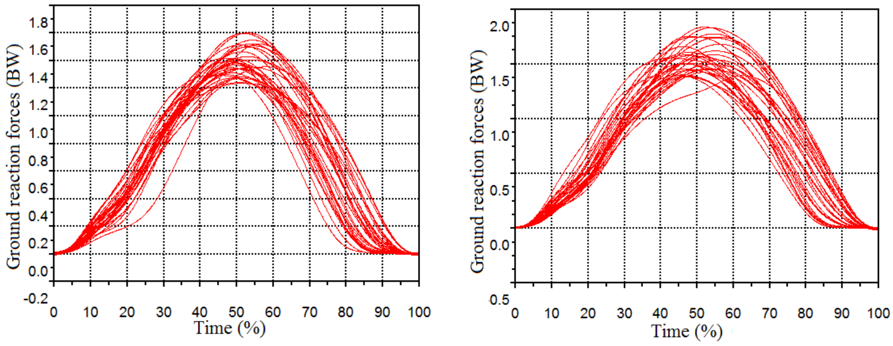

Figure 2 - Force curves in both immersion levels: sternum (left) and hip (right) when performing the underwater running.

Table 1 shows values of mean, standard deviation and coefficient of variation for the variables vertical component of GRF (Fy), contact time and impulse for both immersion levels.

Table 1 - Values of mean, standard deviation and coefficient of variation of vertical component of GRF (Fy), contact time and impulse for both immersion levels.

Immersion Level	Force Peak (FP)			Contact Time (s)			Impulse (N/BW.s)		
	$\bar{X}$	s	cv	$\bar{X}$	S	cv	$\bar{X}$	s	Cv
Sternum	1.38	0.11	8,17	0.39	0.03	7.29	0.26	0.01	5.64
Hip	1.55	0.15	9.40	0.39	0.03	7.07	0.30	0.02	6.80

*** $\bar{X}$, average; s, standard deviation; cv, coefficient of variation (%); s, seconds; BW, body weight.**

Results of the accumulated coefficient analysis are presented in Figure 3. It was observed a stabilization of the values of variables starting in the 6th passage in the walkway. In order to guarantee quality of data one suggests collecting 10 valid passages for each subject in situation.

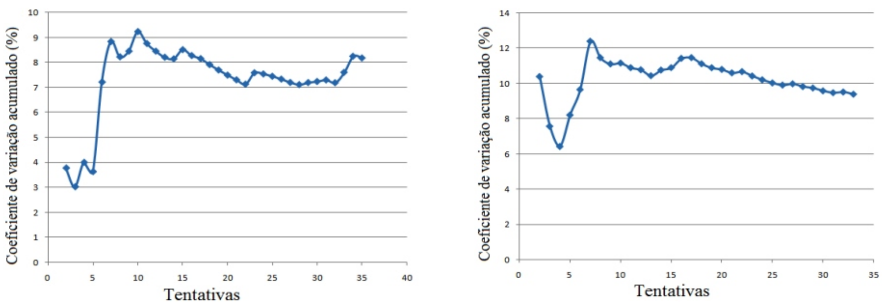

Figure 3 - Accumulated coefficient of variation curves to force peak: sternum level (left) and hip level (right)

After determining the number of executions (10 passages), all of the 30 executions were divided in three groups of 10 passages each. Table 2 shows values of mean, standard deviation and coefficient of variation for the variables force peak, contact time and impulse.

Table 2 - Average values of the force peak, contact time and impulse for the three groups

Immersion Level		Force Peak (BW)			Contact Time (s)			Impulse (N/BW.s)		
		$\bar{X}$	s	cv	$\bar{X}$	s	cv	$\bar{X}$	s	Cv
Sternum	**Group 1**	1.41	0.13	9.22	0.39	0.03	9.03	0.27	0.01	3.07
	Group 2	1.37	0.07	5.38	0.39	0.03	7.76	0.25	0.01	5.10
	Group 3	1.37	0.13	9.14	0.38	0.03	7.03	0.26	0.02	7.52
Hip	**Group 1**	1.54	0.17	11.16	0.38	0.03	7.66	0.30	0.02	6.89
	Group 2	1.61	0.17	10.53	0.38	0.03	8.91	0.30	0.02	7.70
	Group 3	1.52	0.09	6.21	0.39	0.02	5.14	0.30	0.02	6.54

*** $\bar{X}$, average; s, standard ; cv, coefficient of variation (%); s, seconds; BW, body weight.**

Statistical analysis showed data are homogeneous and presented a normal distribution. Thus analysis of variance was carried out to compare the groups of execution. No significant difference was found between the groups for both immersion levels.

CONCLUSION

Through this methodology one suggests data collection of dynamic variables in underwater running should be sampled at 200 points per second and low-pass filtered at a cut-off frequency of 20 Hz; subjects should perform 10 valid passages for each analyzed situation.

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DETERMINATION OF THE ACQUISITION RATE AND THE NUMBER OF STEPS TO BE COLLECTED FOR THE RACE ANALYSIS IN AQUATIC ENVIRONMENT

ABSTRACT

This study aimed to determine the sampling rate, the filtering cut-off frequency and the number of executions for data collection of dynamic variables in underwater running. A 27-year-old male subject participated of this study (1,80m of height and 84,3kg of body mass. A force plate was placed at the bottom of a thermal swimming pool (30±1°C) between boxes that formed an 8-meter walkway. The force plate was sampled at 1000 points per second. After the anthropometrical measurements, the subject was asked to enter in the pool was instructed to walk over the walkway in two distinct immersion levels: hip and sternum. Data were exported and treated through Scilab (INRIA) software. Data were analyzed through descriptive and inferential statistics. When analyzing the result of spectral density curve (Figure 1), it was observed that data could be collected with a sampling rate of 200 points per second, 10 times higher the signal frequency, which guarantees its integrity during acquisition. These results could also be used to set the filtering cut-off frequency of 20 Hz, once the original signal's frequency is lower than the cut-off frequency. Results of the accumulated coefficient analysis are presented in Figure 3. It was observed a stabilization of the values of variables starting in the 6^{th} passage in the walkway. In order to guarantee quality of data one suggests collecting 10 valid passages for each subject in situation.

KEY WORDS: biomechanics, rehabilitation, hidrogymnastcis, underwater running.

DETERMINATION DU TAUX D'AQUISITION ET DE LA QUANTITE DE PASSAGE POUR L'AQUISITION DE DONNEES DANS LA COURSE SUBAQUATIQUE.

RESUMÉ

L'objectif de ce travail a été déterminer le taux d'acquisition, la fréquence du filtre et le nombre de passage a acquérir pour l'analyse du torseur de force dans la course au environnement aquatique. Un sujets du sexe masculin a participé de l'étude, avec 27 ans d'âge, 1.80 m de stature et 84.3 kg de masse. Dans le fond d'une piscine thermique (30 ± 1oC) a été placée une plate-forme de force subaquatique dans une couloir de 8 m de longueur. On a utilisé un taux d'acquisition de 1000 points par second. Après les mesures, le sujet est entré dans la piscine, a eu le temps nécessaire pour se familiariser avec l'équipement et a été instruit à courir à les suivants niveaux d'immersion : processus xiphoïde et hanche. Aprés l'acquisition les données ont été exportées pour être traités avec le logiciel Scilab (INRIA). On a utilisées la statistique descriptive et inférentielle (ANOVA, $p<0,05$). Avec le résultat de la courbe de densité spectrale, on a caractérisé que les données peuvent être rassemblées tranquillement avec une taux de 200 points par second, 10 fois la fréquence du signal, ce qui garantit son intégrité pendant l'aquisition. La fréquence du filtre utilisé peut être autour de 20 Hz, cet aussi garantit l'intégrité du signal, vu que le signal est contenu dans une fréquence au-dessous de la fréquence de coupage du filtre. Le résultat des courbes du coefficient de variation accumulé montre la stabilisation des variables entre le sixième et le septième passage du participant. Pour que aient une marge de sécurité, on fait la sugestion de acquérir 10 passages pour chaque personne dans chaque situation.

MOTS CLES: Biomécanique, réhabilitation, exercices sur l'eau, course.

DETERMINACIÓN DE LA TASA DE ADQUISICIÓN Y EL NÚMERO DE PASOS QUE DEBE RECOGERSE PARA LA ANÁLISIS DE CARRERA EN EL MEDIO AMBIENTE ACUÁTICO

RESUMEN

El objetivo del estudio fue determinar la tasa de adquisición, la frecuencia de corte de filtro y el número de pasos necesarios en el dinamométrico análisis de la marcha submarina. Un sujeto masculino participa en este estudio: 27 años de edad, 1,80m de alto y 84,3kg de masa. En la parte inferior de una piscina de temperatura controlada, una plataforma de fuerza submarina fue colocada entre un pasillo con 8m de longitud. Se utilizó una tasa de adquisición de 1000 puntos por segundo. Después de la medición antropometría, tenía el tiempo necesario para hacer a familiar sí mismo al equipo y fue mandado correr en los niveles siguientes de la inmersión: cadera y esternón. Con posterioridad a la adquisición, los datos habían sido exportados y tratados en el software de Scilab (INRIA). La estadística descriptiva e inferencial fue utilizada (ANOVA, $p<0,05$). Con el resultado de la curva de la densidad espectral fue caracterizado que los datos se pueden recoger tranquilamente con una frecuencia de 200 puntos para los segundos, 10 por la frecuencia de la señal, qué garantiza su integridad durante la colección. Por otra parte podría frecuencia del filtro usado, que puede ser alrededor 20hz qué también garantiza la integridad de la señal, una época que la señal está contenida en una frecuencia abajo de la frecuencia del corte del filtro. El resultado de las curvas del coeficiente de variación acumulado evidencia la estabilización de las variables del sexto para el séptimo pasajes del participante. Para tener un margen de seguridad, se sugiere para recoger 10 pasajens válidos para cada participante en cada situación.

PALABRAS-CLAVE: Biomecánica, reabilitación, ejercicios en el agua, corrida

DETERMINAÇÃO DA TAXA DE AQUISIÇÃO E DO NÚMERO DE PASSOS PARA COLETA DE DADOS NA CORRIDA SUBAQUÁTICA.

RESUMO

O objetivo deste trabalho foi determinar a taxa de aquisição, a freqüência de corte do filtro e o número de passos a serem coletados para a análise dinamométrica da corrida em ambiente aquático. Participou do estudo um sujeito do sexo masculino, com 27 anos de idade, 1,80 m de estatura e 84,3 Kg de massa. No fundo de uma piscina térmica (30 ± 1°C) foi colocada uma plataforma de força subaquática numa passarela de 8 m de comprimento. Foi utilizada uma taxa de aquisição de 1000 pontos por segundo. Após as medições o sujeito entrou na piscina, teve o tempo necessário para familiarizar-se com o equipamento e foi instruído a correr nos seguintes níveis de imersão: processo xifóide e quadril. Posteriormente a aquisição, os dados foram exportados para serem tratados no software Scilab (INRIA) Foi utilizada a estatística descritiva e inferencial (ANOVA, $p<0,05$). Através do resultado da curva de densidade espectral foi caracterizado que os dados podem ser coletados tranqüilamente com uma freqüencia de 200 pontos por segundo, 10 vezes a freqüencia do sinal, o que garante sua integridade durante a coleta. Além disso pôde-se a frequencia do filtro utilizado, a qual pode ser em torno de 20 Hz o que também garante a integridade do sinal, uma vez que o sinal está contido numa freqüência abaixo da freqüência de corte do filtro. O resultado das curvas do coeficiente de variação acumulado evidencia a estabilização das variáveis a partir da sexta para a sétima passagem do participante. Para se ter uma margem de segurança, sugere-se coletar 10 passagens válidas para cada indivíduo em cada situação.

PALAVRAS CHAVES: Biomecânica, reabilitação, exercícios aquáticos, corrida.