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The aim of this study was to analyze the relationships between "Sailor's jigs" kinematics and increasing music cadence. Six young women, non-pregnant, with at least one year of experience conducting this type of head-out aquatic program, with no kind of skeletal muscle injury reported in the last six months were evaluated. The exercise was recorded on video, in the frontal plane, using a pair of cameras, enabling a double projection, from above and underwater body motions, at five increasing cadences (120 b.min^{-1}, 135 b.min^{-1}, 150 b.min^{-1}, 165 b.min^{-1} and 180 b.min^{-1}). Images were thereafter digitized in specific software (Ariel Performance Analysis Systems). The cycle period decreased through the incremental protocol. Cycle period decrease is done decreasing joint range of motion and increasing the limbs segmental velocity as well. Although these combined kinematical strategy, a deeper analysis reveals that subjects decrease the cycle period mainly decreasing the range of motion.

Introduction

Head-out aquatic classes are often full with dozens of subjects, giving instructors a greater challenge to maintain synchronization. Instructors use music cadence on a regular basis for such purpose. Added to that, music's melody and cadence are a way to motivate subjects, achieving a given intensity of exertion (Kinder and See, 1992).

Basic head-out aquatic exercises are categorized in six main groups (Sanders, 2000): (i) walking; (ii) running; (iii) rocking; (iv) kicking; (v) jumping and; (vi) scissors. Some researchers analyzed the relationships between musical cadence and some of those basic head-out aquatic exercises (e.g., Oliveira et al., 2010; in press). However, it seems none of them focused on the "sailor's jigs" exercise.

The aim of this study was to analyze the relationships between "sailor's jigs" kinematics and increasing music cadence. It was hypothesized that increasing musical cadence will decrease the cycle period and, therefore, the segmental range of motion.

Methods

Subjects: Six young women, non-pregnant, clinically healthy and physically active, holding a graduate degree in Sports Sciences and with at least one year of experience conducting head-out aquatic classes, volunteered to participate in this study (23.50 ± 3.51 years-old; 57.17 ± 4.07 kg of body mass; 1.66 ± 0.06 m of height; 20.60 ± 0.55 kg/m^2 of body mass index; 270.00 ± 80.50 minutes of aquatic fitness classes per week). Subjects reported no previous history of orthopedic or muscle-skeletal injuries in the previous six months. All procedures were in accordance with the Declaration of Helsinki with respect to human research. The Institutional Review Board of the Polytechnic Institute of Bragança approved the study design. Women were informed of the experimental risks and signed an informed consent document before the investigation.

Procedures

Each subject performed a basic head-out aquatic exercise named "sailor's jigs". The exercise was performed using "water tempo" according to the standard recommendations from the technical literature (Kinder and See, 1992) that was already reported in some scientific papers as well (e.g., Barbosa et al., 2010a).

The protocol consisted of five sets of 16 full repetitions of the "Sailor's jigs" exercise, at "water tempo", immersed to the xiphoid process (i.e., breast). The intensities of the bouts were 80 [%], 90 [%], 100 [%], 110 [%] and 120 [%] of the cadence reported by Barbosa et al. (2010a) to achieve a 4 [mmol.l^{-1}] of blood lactate, representing 120 [b.min^{-1}], 135 [b.min^{-1}], 150 [b.min^{-1}], 165 [b.min^{-1}] and 180 [b.min^{-1}], respectively. The musical cadence was electronically controlled by a metronome (Korg, MA-30, Tokyo, Japan) connected to a sound system. Whenever necessary, the evaluators gave verbal and/or visual cues for subjects to follow the appropriate exercise cadence and accomplish the number of repetitions asked. All subjects completed the protocol's five bouts. The water temperature was 30ºC and the relative humidity was 75 [%].

Data Collection

The protocol was videotaped independently in the frontal plane with a pair of cameras providing a dual projection from both underwater (GR-SXM25 SVHS, JVC, Yokoama, Japan) and above (GR-SX1 SVHS, JVC, Yokoama, Japan) the water surface as reported elsewhere (Oliveira et al., 2010; in press). The study included kinematical analysis of the full exercise cycle (Ariel Performance Analysis System, Ariel Dynamics Inc., USA) through a VCR (Panasonic, AG 7355, Japan) with a sampling rate of 50 [Hz]. Zatsiorsky's model adapted by de Leva (1996) was used, dividing the trunk in two articulated segments and including an overall number of nineteen body landmarks to be digitized in each frame. To create a single image of dual projection, as described previously (Barbosa et al., 2010b) the independent digitalization from both cameras was reconstructed with the help of a calibration object (1.50 x 0.85 m; 6 control points) and a 2D-DLT algorithm (Abdel-Aziz and Karara, 1971). For the analysis of the curve of the center of mass kinematics, a filter with a 5 [Hz] cut-off frequency was used and for the segmental kinematics 9 [Hz] was used. A double-passage filtering for the signal processing was performed. Assessed were the: (i) cycle period (P, s); (ii) range of motion ($\Delta\phi$, º) of the thigh-trunk, lower leg-thigh, upper arm-arm from left and

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right sides and; angular velocity (ω, °/s) thigh-trunk, lower leg-thigh, upper arm-arm from both sides.

Statistical Procedures

The normality of the distribution was assessed with the Shapiro-Wilk test. For descriptive analysis, mean plus one standard deviation were computed as central tendency and dispersion measures, respectively. For each relationship, the mathematical model with the best good-of-fit adjustment and the lowest standard error of estimation was adopted. All relationships presented a better adjustment when linear regressions were computed. So, linear regression models were used to describe the relationships between musical cadence and selected kinematical variables, as well as, its coefficients of determination. As rule of thumb, for qualitative and effect size assessments, it was defined that the relationship was: (i) very weak if $R^2 < 0.04$; weak if $0.04 \leq R^2 < 0.16$; moderate if $0.16 \leq R^2 < 0.49$; high if $0.49 \leq R^2 < 0.81$ and; very high of $0.81 \leq R^2 < 1.0$. The level of statistical significance was set at $P \leq 0.05$.

Results and Disscussion

There was a significant, negative and very high relationship between P and musical cadence ($R^2 = 0.77$; $P < 0.01$). This means that increasing cadences imposed a decrease in the absolute duration of a full exercise. Decreasing time to perform a full exercise can be obtained: (i) decreasing the joint's Δϕ and maintaining the ω or; (ii) maintaining the joint's Δϕ and increasing the ω or; (iii) combining both. So, it is useful to assess both angular displacements and velocities for upper and lower limbs, in order to make it clear.

There was a decrease in the Δϕ (e.g., right side thigh-leg: $R^2 = 0.286$; $P = 0.002$; left side thigh-leg: $R^2 = 0.141$; $P = 0.041$; left side upper arm-arm: $R^2 = 0.135$; $P = 0.046$) with increasing musical cadences. In the same way there was a trend for the increase of the ω with increasing musical cadence but with no statistical meaning for most selected variables, except for the right side thigh-trunk ($R^2 = 0.133$; $P = 0.047$). So, decreasing the cycle period is achieved through a combination of decreasing the Δϕ and increasing the ω. Although the combined kinematical strategy, a partial comparison to analyze the most determinant behavior (i.e., if the decrease of Δϕ or the increase in the ω) reveals that subjects decrease the cycle period mainly decreasing joint range of motion.

Conclusion

The increase of musical cadence imposed a decrease of the cycle period and; the cycle period changed the limb's kinematics, mainly imposing a Δϕ decrease. As practical implication, instructors should choose musical cadences according to subject's fitness level, avoiding cadences that impose a significant decrease of the full Δϕ. Plus, they should always give verbal and/or visual cues for subjects to perform the exercises through full range of motion, following the selected exercise cadence.

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