



Original

## Cardiorespiratory responses during deep water running with and without horizontal displacement at different cadences



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### ABSTRACT

**Objective:** To compare the cardiorespiratory responses during deep water running with and without displacement at different cadences.

**Methods:** Twelve young women performed deep water running with and without displacement during 4 min at three separate cadences: (a) 60 bpm; (b) 80 bpm; and (c) 100 bpm. The heart rate (HR), ventilation ( $V_e$ ) and oxygen uptake ( $VO_2$ ) were collected in the last minute of each test. Two-way ANOVA for repeated measures was used with Bonferroni's post hoc test ( $p < 0.05$ ) to compare variables.

**Results:** The results showed a significant increase in all variables as the cadence increased (HR:  $p < 0.001$ ;  $V_e$ :  $p < 0.001$ ;  $VO_2$ :  $p < 0.001$ ). In addition, the  $VO_2$  and  $V_e$  values were significantly higher for deep water running with displacement compared to running without displacement ( $VO_2$ :  $p = 0.047$ ;  $V_e$ :  $p = 0.007$ ). However, there was no significant difference in HR with and without displacement ( $p = 0.065$ ).

**Conclusions:** The results indicate that the increase in both cadence and displacement results in significant cardiorespiratory responses as a result of deep water running. This finding is important for adapting exercise prescription to the goals of participants.

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## Respuestas cardiorrespiratorias de la carrera en aguas profundas con y sin desplazamiento horizontal y en diferentes cadencias

### RESUMEN

**Objetivo:** comparar las respuestas cardiorrespiratorias durante la carrera en aguas profundas con y sin desplazamiento horizontal y a diferentes cadencias.

**Método:** Doce mujeres jóvenes realizaron la carrera en aguas profundas con y sin desplazamiento durante cuatro minutos a tres cadencias diferentes: a) 60 bpm, b) 80 bpm, y c) 100 bpm. La frecuencia cardíaca (FC), la ventilación (VE) y el consumo de oxígeno ( $VO_2$ ) se recogieron en el último minuto de cada prueba. ANOVA de dos vías para medidas repetidas con post hoc de Bonferroni ( $p < 0,05$ ) se utilizaron para comparar las variables.

**Resultados:** Los resultados mostraron un aumento significativo en todas las variables con el aumento de la cadencia (FC:  $p < 0,001$ ;  $V_e$ :  $p < 0,001$ ;  $VO_2$ :  $p < 0,001$ ). Además, los valores de  $VO_2$  y  $V_e$  fueron significativamente mayores para la carrera en aguas profundas que se ejecuta con desplazamiento en comparación con la realizada sin desplazamiento ( $VO_2$ :  $p = 0,047$ ;  $V_e$ :  $p = 0,007$ ). Sin embargo, no hubo diferencia significativa en FC con y sin desplazamiento ( $p = 0,065$ ).

**Conclusiones:** Los resultados indican que el incremento de la cadencia y el desplazamiento proporcionan importantes respuestas cardiorrespiratorias en la carrera en aguas profundas.

#### Palabras clave:

Ambiente acuático

Mujeres jóvenes

Frecuencia cardíaca

Ventilación

Consumo de oxígeno

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Este hallazgo es importante para la adaptación de la prescripción de ejercicio de acuerdo con los objetivos de los participantes.

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## Respostas cardiorrespiratórias durante a corrida em piscina funda com e sem deslocamento horizontal em diferentes ritmos

### R E S U M O

#### Palavras-chave:

Ambiente aquático  
Mulheres jovens  
Frequência cardíaca  
Ventilação  
Consumo de oxigênio

**Objetivo:** comparar as respostas cardiorrespiratórias durante corrida em piscina funda profunda com e sem deslocamento horizontal em diferentes ritmos.

**Métodos:** Doze mulheres jovens realizaram corrida aquática com e sem deslocamento durante quatro minutos, em três ritmos distintos: a) 60 bpm; b) 80 bpm; e c) 100 bpm. A frequência cardíaca (FC), ventilação (VE) e o consumo de oxigênio ( $VO_2$ ) foram coletados no último minuto de cada teste. Two-way ANOVA para medidas repetidas foi utilizada com o teste post hoc Bonferroni's ( $p < 0,05$ ) para comparar as variáveis.

**Resultados:** Os resultados mostraram aumentos significativos em todas as variáveis conforme o aumento do ritmo (FC:  $p < 0,001$ ; VE:  $p < 0,001$ ;  $VO_2$ :  $p < 0,001$ ). Além disso, os valores de  $VO_2$  e VE foram significativamente maiores para corrida aquática com deslocamento em relação à corrida sem deslocamento ( $VO_2$ :  $p = 0,047$ ; VE:  $p = 0,007$ ). No entanto, não houve diferença significativa na FC com e sem deslocamento ( $p = 0,065$ ).

**Conclusões:** Os resultados indicam que o aumento do ritmo e deslocamento proporcionam importantes respostas cardiorrespiratórias na corrida em piscina funda. Este achado é importante para adaptar a prescrição de exercícios conforme os objetivos dos participantes.

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## Introduction

The study of cardiorespiratory responses in aquatic exercise has gained attention in recent years, mainly to improve the prescription of these activities. Swimming, water-based exercise and deep water running can be highlighted as activities developed in an aquatic environment. Such activities have been recommended due to their physical fitness benefits,<sup>1</sup> lower cardiovascular demand<sup>2,3</sup> and reduced impact on the joints of the lower limbs.<sup>4–9</sup>

Deep water running is performed with the aid of a floatation vest that keeps the individual upright and does not allow the feet to rest on the bottom of the pool.<sup>10</sup> This exercise can be performed with or without displacement. Moreover, deep water running can be an effective form of cardiovascular conditioning for both injured athletes and individuals who need aerobic exercise without impact on the joints of the lower limbs.<sup>11</sup>

Several studies have shown that exercise involving vertical displacement, such water-based exercise, and an increase in cadence result in a rise in angular velocity and, consequently, oxygen uptake ( $VO_2$ ) and heart rate (HR).<sup>1,12–15</sup> These responses also have been found with increasing linear velocity in horizontal displacement exercises, such as water walking.<sup>16–20</sup> However, in deep water running, it is not yet clear which factors directly influence the increase in cardiorespiratory responses at submaximal intensities. According to studies previously cited, the increase in exercise intensity, either by cadence (angular velocity) or speed (linear velocity), maximizes the cardiorespiratory response, largely because the drag force increases with the increase in velocity.<sup>21</sup>

Furthermore, an increase in the projected frontal area increases the resistance of the movement, contributing to elevated cardiorespiratory responses. In deep water running, resistance can be increased by using different arm movements<sup>22</sup> and alternating

running with and without displacement.<sup>3</sup> In this way, Kanitz et al.<sup>3</sup> compared deep water running with and without displacement in a submaximal cadence of 80 bpm. The authors observed no significant differences in  $VO_2$ , energy expenditure (EE) or perceived exertion (PE) and stated that the low linear velocity of horizontal displacement at a submaximal cadence (80 bpm) may have contributed to the resistance, which was maximized to influence other variables.

Although there is interest in evaluating cardiorespiratory responses during deep water running, there are few studies that have analyzed responses to different intensities and execution forms. There are many factors that influence cardiorespiratory variables during water immersion, causing different physiological responses or varying interpretations in study conclusions. It is important to highlight these influences so that fitness professionals can appropriately prescribe exercises performed in an aquatic environment.

Due to the growing number of participants in varying types of water exercise, it is necessary to understand the physiological responses so that water exercise programs, such as deep water running, can be adapted to the goals of the participants. Thus, the aim of the present study was to compare cardiorespiratory responses for young women during deep water running with and without displacement at different cadences.

## Methods

### Subjects

The sample was composed of twelve young, physically active women between 19 and 26 years of age. Subjects were selected through verbal invitation to scholarship holders within a

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