Oxygen consumption in wheelchair fencing. Direct assessment and validation of an estimation method

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Abstract

There is little scientific evidence on the physiological responses to wheelchair fencing (WF), with most focusing on able bodied fencing. Direct measurement of physiological responses to WF is practically non-existent and little is known about the energy requirements in a competition of this Paralympic modality. Being able to estimate oxygen consumption (VO2) from heart rate (HR) will enable us to better understand the demands of competition when only HR is able to be measured. **PURPOSE**: To determine the cardiorespiratory demands of wheelchair fencing and validate an estimation method based on HR. **METHODS**: We analysed 11 (7 class A & 4 class B) wheelchair fencing athletes (27.6 ±7.4 yrs) with 8.7 ±4.8 years of experience and 13 ± 7 hours of weekly training in 3 phases: 1) A WF specific progressive test of 5 submaximal stages measuring HR (Polar H10) and VO2 (K5 Cosmed); 2) a training fight up to 15 hits with direct measurements of VO2; 3) HR was recorded during a simulated WF competition. VO2, HR, lactate (La-) and perception of effort (RPE 1-10) were recorded at various time points. An equation to estimate VO2 for each fencer was calculated in phase 1 with the direct measurements of VO2 and HR using linear regression. In Phase 2, this relationship was validated by comparing the direct measurement of VO2 with the estimated measurement of VO2 based off HR using Pearson correlations. HR data from phase 3 was then used to estimate VO2 for the épée competition in training. **RESULTS**: The estimated VO2 presents values lower than the real VO2 by 9.9% with good correlation indices (r= 0.843, p<.001). The direct measurement of VO2 during the WF fights was 23.3 ±6.1 ml·min-1·kg-1 and VO2max was 32.1 ±7.9 ml·min-1·kg-1. The average HR (HRmean) as a percentage of age predicted maximum was 72.7 ±10.3% and HRmax was 81.7 ±10.4%. The post-fight La- values were 3.5 ±3.6 mmol·min-1, general RPE 4.8 ±3.2, and RPE of the sword arm 3.3 ±2.5. The estimated VO2 in a simulated competition was 21.8 ±6.5ml.min-1.kg-1, and the VO2max was 30.1 ±8.4 ml.min-1.kg-1. HRmean was 74.6 ±7.8% and HRmax 89.0 ±8.6%. **CONCLUSION**: The physiological demands of wheelchair fencing are lower than those for able bodied fencing. We can use HR to estimate VO2 in wheelchair fencing, but the values are slightly underestimated.

Background

There is little scientific evidence on the physiological responses to wheelchair fencing (WF), most focusing on injury typology or functional classification criteria. There is a previous study to assess the cardiopulmonary requirements of WF however it was performed with able bodied fencers (Iglesias et al., 2019). Direct measurement of physiological responses to WF is practically non-existent and little is known about the energy requirements in a competition of this Paralympic modality. Being able to estimate oxygen consumption (VO_2) from heart rate (HR) will allow us to better understand the demands of competition when only HR can be measured.

Purpose

To determine the cardiorespiratory demands in wheelchair fencing bouts and to validate a method for estimating oxygen consumption based on individual heart rate.

Methods

The study has Informed consent of the participants and the authorization of an Ethics Committee (012020CEICEGC, February 10, 2020). We analyzed 11 WF athletes (7 class A and 4 class B) (27.6 ± 7.4 years old) with 8.7 ± 4.8 years of experience and 13 ± 7 hours of weekly training in 3 phases:

Phase 1

A specific WF progressive test (n=11) of 5 submaximal stages in which a lunge was performed to a lunge pad and a retreat with 2 Parries (4th + 6th) was performed consecutively and progressively, measuring HR (Polar H10) and VO_2 (K5 Cosmed), lactate (La^-) and perceived exertion (RPE 1-10). An equation was calculated to estimate the VO_2 of each fencer with direct measurements of VO_2 and HR [VO_2=a+(b·HR)].

Phase 2

A training bout (n=11) of up to 15 hits with direct measurements of VO_2 and HR, and final La^- and RPE was performed. The VO_2 estimation method was validated by comparing the direct VO_2 measurement in this bout with the individually estimated VO_2 by the equation described in phase 1. The direct values were correlated with the VO_2 estimates

Phase 3

A WF training épée competition (n=7) was performed with direct measurement of HR and final records of La^- and RPE. The VO_2 values in the competition were estimated by applying the linear regression of phase 1. The bout and rest times were verified by means of observation sheets and verification with the LINCE PLUS software (Soto-Fernández et al., 2022).

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References

1. Iglesias X. et al. (2019) J Sport Med Phys Fit 59:569-574
2. Soto-Fernández A. et al. (2022) Behav Res 54:1263-1271

Results

Figure 1. HR and VO_2 values in a specific wheelchair fencing test

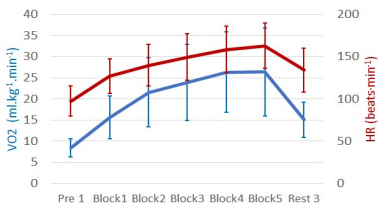

Figure 2. Relationship (subject 1) HR & VO_2 - wheelchair fencing test

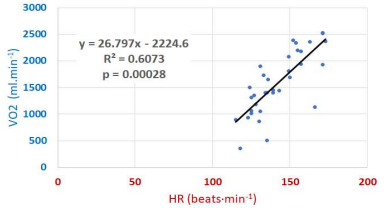

Table 1. Results of wheelchair fencing bouts with direct measurement of VO_2 (Values are: mean ± sd; max - min)

VO_2 ml·kg^{-1}·min^{-1}	HR beats·min^{-1}	% HR_{max} %	Lactate mmol·L^{-1}	RPE (1-10)
23.3 ± 6.1	139.8 ± 19.9	72.7 ± 10.3	3.5 ± 3.6	4.9 ± 3.0
5.2 - 47.6	75.0 - 190.0	38.3 - 93.8	1.4 - 13.9	1.0 - 10.0

Figure 3. Relationship VO_2real & VO_2estim - wheelchair fencing bouts

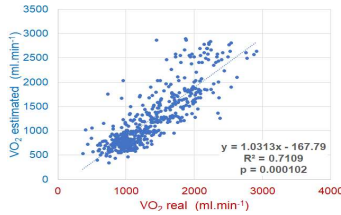

Figure 4. VO_2estimated in a wheelchair fencing training competition

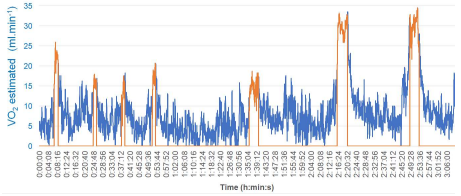

Table 2. Results in a wheelchair fencing training competition (Values are: mean ± sd; max - min)

VO_2 estimated ml·kg^{-1}·min^{-1}	HR beats·min^{-1}	% HR_{max} %	Lactate mmol·L^{-1}	RPE (1-10)
21.8 ± 4.4	143.9 ± 14.4	74.6 ± 7.5	4.0 ± 2.7	5.0 ± 2.4
4.6 - 44.5	75.5 - 201.3	41.3 - 100	1.9 - 8.5	1.0 - 8.0

Discussion & Conclusions

- **The physiological demands of wheelchair fencing are lower than those of standing fencing, but the demands on disabled people in wheelchair fencing bouts are similar to those of abled bodied people in the same conditions (wheelchair fencing).**
- **We can use HR to estimate VO_2 in wheelchair fencing: the values are slightly underestimated (9.9%) but with good correlation indices (r= 0.843, p < 0.001).**