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Local Muscle Oxygenation Differences between Lower Limbs according to Muscle Mass in Breath-Hold Divers

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Abstract: Oxidative potential and anaerobic capacity could be influential to the training regimen and performance of breath-hold diving (BHD) athletes. Therefore, this study aimed to determine the differences in local muscle oxygenation between the lower limbs according to the muscle mass percentage in spearfishermen and freedivers. The sample of participants included 21 BHD athletes (13 freedivers; 8 spearfishermen; 4 females). Their chronological age was 35.5 ± 8.6 years, body mass was 79.3 ± 9.1 kg, and height was 182.5 ± 13.0 cm. Participants' training experience was 10.6 ± 9.5 years. The variables in this study included anthropometric indices, the Wingate anaerobic test, and muscle oxygen dynamics parameters. The results show significant differences for freedivers between the lower limbs (muscle mass percentage, $p < 0.00$; minimal SmO_2%, $p = 0.05$; and maximal SmO_2%, $p = 0.04$). However, when observing only spearfisherman, there is only one significant difference between the dominant and non-dominant lower limb (percentage of lower limb muscle mass, 85.73 ± 2.42, 85.16 ± 2.40%, respectively; $p = 0.02$). The results of this study demonstrate that freedivers have significant asymmetries between the lower limbs in muscle oxygenation parameters when observing the lower limb dominance in relation to the percentage of muscle mass. These findings suggest different muscular oxygenation adaptations to the load set upon athletes.

Keywords: freediving; spearfishing; muscle oxygen saturation; Wingate test; vastus lateralis

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1. Introduction

Human preference for using one side of the body during motor tasks is a common tendency while performing. This tendency characterizes the lateral preference [1]. Furthermore, lateral preference is influential to the asymmetries that occur during the performance of motor tasks and skills [2]. Even for doe, which is a lateralization of the body that is developed early in life, it is suggested that only 10–20% depends on genetics, whereas 80–90% are subject to environmental factors [3]. These factors are defined as task complexity [4,5], gender [4,6], and developmental characteristics [7]. A previously performed study demonstrates how predominantly symmetrical or asymmetrical sports influence body asymmetries, mainly because of the body's adaptation to the demands during sport-specific training [8]. In addition, different activities show different symmetries between both body sides [9–11]. These asymmetries are mainly assessed via muscle mass, jump height, and maximal force between the body sites [12]. However, other factors could serve as asymmetrical indicators, one of which is local muscle oxygenation.

Previous studies demonstrate a significant difference between the lower limbs in muscle oxygenation parameters during different activities [13–15]. Additionally, these studies used near-infrared spectroscopy (NIRS) as an assessment tool for the determination of the above-mentioned differences. NIRS is a non-invasive assessment tool for viewing changes in oxygenation and hemodynamics in the skeletal muscle tissue [16,17]. Briefly, NIRS provides muscle oxygenation and blood volume metrics and can estimate muscle oxygen saturation (SmO_2), reflecting the balance between oxygen delivery and utilization in response to exercise in the exact portion of the muscle under the sensor [18]. Precisely, SmO_2 reflects the dynamic balance between O_2 supply and O_2 consumption and is independent of the path of the near-infrared photon in muscle tissue; its values range from 1% to 100% [19].

A review of the literature on the topic of oxygenation differences displayed the correlation of SmO_2 asymmetry/symmetry with different parameters such as injury rate [20], strength [15], performance [14], and the influence of sport [21]. Moreover, Vasquez-Bonilla, Brazo-Sayavera, Timón and Olcina [20] demonstrated that footballers who suffered injuries had a higher asymmetry oxygenation slope difference than those without injuries. Also, <15% of asymmetry explained a greater probability of injury. Therefore, the authors propose such a protocol as a novel approach to the determination and prevention of injuries. According to Hettinga, Konings and Cooper [13], speed skaters perceive a difference between muscle oxygenation and recovery time during a single lap of the race. Such asymmetry is influenced by the nature of the sport but could potentially influence faster fatigue on longer tracks. Previous studies on muscle oxygenation asymmetries mainly include speed skaters. Therefore, it could be valuable to examine such asymmetries for other athletes who are enduring different types of loads. These effects have not been assessed in breath-hold divers (BHD) so far, and even the doe symmetry of the lower limbs could potentially play a pivotal role in the performance of these athletes.

BHD disciplines include (a) freediving in which athletes perform static apnea (the longest duration diver can hold their breath, usually lasting for more than 4 min), dynamic apnea (in which divers swim horizontally underwater for a maximal distance in a pool), and depth diving (performed in the sea, which describes the means of descent and ascent); and (b) spearfishing conducted in the sea, where divers are allowed ~5–6 h to search and catch as many fish as possible. Physiological adaptations during breath-hold diving are characterized by the resistance of reactive oxygen species, reduced sensitivity to hypoxia, and low mitochondrial oxygen consumption [22]. Furthermore, physiological responses that occur during deep dives demonstrate the coordination of oxygen conservation, exercise economy, and hyperbaric management [23]. Apart from this, it was previously demonstrated that lactate levels rise after the dive [24]. In enduring this unnatural environment, BHD athletes have to be adequately trained [24]. Therefore, the diagnostics of anaerobic capacities should provide valuable information for these athletes. Following that, the gold standard test that determines anaerobic capacities is the Wingate anaerobic test (WAnT) [25]. WAnT has shown to be an intense exercise stimulus based mainly on anaerobic metabolism; however, the utilization of oxygen contributes significantly (16–29%) to the provision of energy [26,27]. Accordingly, studies using near-infrared spectroscopy (NIRS) have shown a muscle oxygenation drop in the vastus lateralis muscle while performing WAnT [26,28]. However, there is only one study examining both NIRS and WanT in BHD [29].

Studies that define NIRS measurements in freediving were previously performed on different body sites (especially cerebral) [30,31]. These studies were mostly conducted to determine and understand human physiology in a low-oxygen environment [32–34]. However, there is a need to assess anaerobic capacities in BHD athletes. Firstly, these capacities are highly related to the oxygenation ability of the muscles due to the phosphocreatine degradation process, which is necessary to elicit power [19,28]. Secondly, BHD athletes report a high feeling of fatigue in the lower limb muscles after prolonged dives. Therefore, the determination of muscle oxygenation and lower limb asymmetries could be of use for BHD athletes' performance. To our knowledge, there is a lack of studies that determine these aforementioned factors (e.g., lower limb oxygenation asymmetries) in BHD athletes, and knowledge of oxidative potential and anaerobic capacity could be influential to the training regime. Hence, the authors hypothesize that lower limb muscle oxygenation will show asymmetries in freedivers but not in spearfisherman. Therefore, this study aimed to determine the differences in local muscle oxygenation between the lower limbs according to muscle mass percentage in spearfishermen and freedivers.

2. Materials and Methods

2.1. Participants

The sample of participants included 21 BHD athletes (13 freedivers; 8 spearfishermen; 4 females). Their chronological age was 35.5 ± 8.6 years, body mass 79.3 ± 9.1 kg, and height 182.5 ± 13.0 cm. Participants' training experience was 10.6 ± 9.50 years. Since this study includes two groups of participants, it is considered a cross-sectional, comparative study. The sample of spearfishermen consisted of amateur and national-level competitive athletes. The freedivers sample included athletes that compete on national but also on international levels. Four of them were national champions and national record holders while two were world champions and world record holders. Participants did not have any illness or medical condition that might have prevented them from performing tests. They were informed about the procedures and purpose of the study and signed informed consent before the investigation began. The study was conducted following the declaration of Helsinki and the Ethical Board of the Faculty of Kinesiology, University of Split, Croatia (ethical board number 2181-205-02-05-22-035). The study was performed during the months before the intensive diving season (April–June).

2.2. Variables

The variables in this study included anthropometric indices, the Wingate anaerobic test, and muscle oxygen dynamics parameters.

Anthropometric indices included body height, seated body height, body mass, and body fat percentage. Body mass and body fat percentage were assessed with the bioimpedance scale (Tanita BC 418 scale; Tokyo, Japan). Apart from general indices, the muscle mass percentage of the lower limbs was extracted for each lower limb individually from the bioimpedance scale.

The anaerobic capacity test (Wingate test, WAnT) was performed on a Monark 874E cycle ergometer (Monark Exercise AB, Vansbro, Sweden). The variables used from the test were as follows: peak power (PP), as the indicator of the highest produced power, average power (AP), as an indicator of anaerobic capacity, minimum power (PD), indicating the lowest level of produced power, and power drop (PD), showing the rate of drop in power. They were calculated to be a relative measurement in accordance with participants' body mass as Watt/kg (W/kg), except for PD, which was shown as an absolute value (Watt).

Muscle oxygenation and blood volume change in the lower limb muscles were measured by the commercially available continuous wave NIRS sensor (Moxy Monitor; Fortiori Designs LLC, Hutchinson, MN, USA). The functioning, usage, validity, and reliability of the NIRS sensor have previously been described [35,36]. The main parameter generated from the NIRS sensors is SmO_2, calculated as a ratio of relative oxyhemoglobin and oxymyoglobin and relative deoxyhemoglobin and deoxymyoglobin [35]. Additionally, the following muscle oxygen parameters were calculated: mean SmO_2 (averaged muscle oxygen saturation
2 min before the test), initial desaturation SmO_2 rate (Desat slope) (inclination of the slope at the beginning of the test), minimal SmO_2 (minimal oxygen saturation during the protocol), ½ recovery SmO_2 (half of the time needed for oxygen to reach maximal saturation from minimal), and maximal SmO_2 (maximal oxygen saturation during the protocol). Mean SmO_2 was used as the value to define the Desat slope. Desat slope is a variable that defines the rate at which the muscle uses oxygen during the protocol. Minimal SmO_2 and maximal SmO_2 are variables that influence ½ recovery SmO_2. Therefore, ½ recovery SmO_2 is calculated to determine the time that is needed to fully recover.

2.3. Procedures

An NIRS sensor was placed over the area of the following two muscles: right vastus lateralis and left vastus lateralis, as proposed by previous studies [37,38]. The mentioned muscles were used mainly because they are at the highest contraction during WAnT. The oxygenation of the muscles was measured simultaneously. The appropriate light shield was placed over the NIRS sensor to prevent ambient light intrusion and interference with the sensor reading. The sensor was fixed in place with 3M medical tape. The sampling rate was at the default mode of 0.5 Hz. To be precise, the sampling rate sampled the four wavelengths (680, 720, 760, 800 nm) over 80 cycles every two seconds. The data were gathered using the Moxy Portal app, which provides a data export feature in xlsx format. Participants' body fat percentage was low (14.31 ± 4.11%), and therefore, adipose tissue thickness was considered negligible for the NIRS results.

The Wingate test was preceded by 2 min of rest to determine the oxygen baseline level, and then a standard 5 min warm-up with a load of 1.0 W/kg took place. Next, after 2 min of rest, the athlete performed a 30 s test with the load individually adjusted to body weight (7.5% of body mass). The subject's task was to produce the highest possible cadence after the "Start!" command and to maintain it as high as possible for the test duration. The participants were instructed not to raise their hips from the saddle but to always make their best effort to pedal during the Wingate test [25].

After obtaining the results, the dominant and non-dominant lower limbs were defined using the percentage of muscle mass. Precisely, the lower limb with a higher percentage was defined as the dominant one [39]. This was used for all oxygenation parameters and was placed in statistical analysis as such.

2.4. Statistical Analyses

Descriptive statistics were measured to assess the arithmetic means and standard deviations (SDs) of all measured variables. The K–S (Kolmogorov–Smirnov) test for normality was used to determine the normal distribution of the data. Also, to assess differences between the dominant and non-dominant lower limb variables, a paired T-test was used in both groups of participants. Furthermore, Pearson's correlation was used to define a possible relation between oxygenation parameters and the percentage of muscle mass for each lower limb. Segmented linear regression, together with other oxygen parameters, was used to plot the data (see Figure 1) following a short response delay at the start of the exercise.

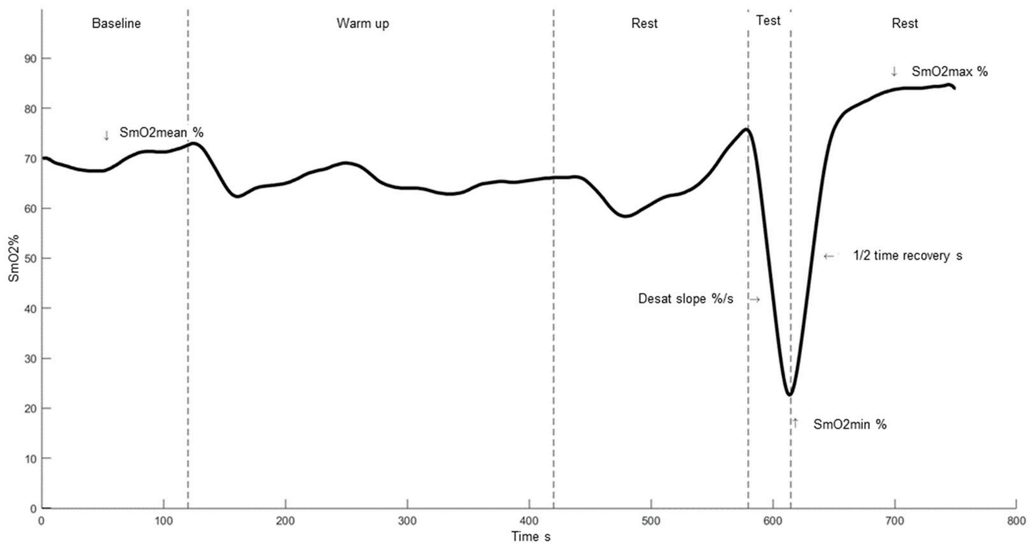

Figure 1. Graphical example of the time course of SmO_2 variables from the resting values during warm-up, test, and rest gathered from the vastus lateralis right muscle.

3. Results

The Kolmogorov–Smirnov test showed that all variables were normally distributed ($p > 0.20$). The results presented in Table 1 show that there are significant differences between the dominant (83.6 ± 6.6) and non-dominant lower limb (83.0 ± 6.7) in muscle mass percentage ($p < 0.00$) in the total sample of participants. Also, oxygenation parameters show significant differences in minimal SmO_2% (dominant (27.4 ± 16.2), non-dominant (19.4 ± 16.5); p = 0.05), maximal SmO_2% (dominant (78.2 ± 4.6), and non-dominant (81.2 ± 5.9); p = 0.01). Freedivers show similar differences for the same variables (muscle mass percentage (p < 0.00), minimal SmO_2% (p = 0.05), and maximal SmO_2% (p = 0.04)). However, when observing only spearfishermen, there is only one significant difference between the dominant and non-dominant lower limb (muscle mass percentage, 85.7 ± 2.4, 85.2 ± 2.4, respectively; p = 0.02). The course of local muscle oxygen levels is presented in Figures 2 and 3, which represent the dominant and non-dominant muscle groups regarding the groups of participants.

Table 1. Descriptive parameters and differences between dominant and non-dominant lower limbs in local muscle oxygenation parameters and muscle mass regarding groups.

All Groups (N = 21)						
Variables	**Dominant Lower Limb**		**Non-Dominant Lower Limb**		**t**	***p***
	Mean	**SD**	**Mean**	**SD**		
Mean SmO_2%	63.7	8.9	65.7	11.3	−1.94	0.07
Desat slope (%/s)	−2.5	1.2	−2.1	1.3	−1.98	0.06
Min SmO_2%	26.8	16.2	29.4	16.5	−2.09	0.05 *
½ time recovery (s)	27.4	17.2	26.9	15.1	0.14	0.89
Max SmO_2%	78.2	4.6	81.2	5.9	−2.75	0.01 *
muscle mass (%)	83.6	6.6	83.0	6.7	6.02	0.00 *
Freedivers (N = 13)						
Variables	**Dominant Lower Limb**		**Non-Dominant Lower Limb**		**t**	***p***
	Mean	**SD**	**Mean**	**SD**		
Mean SmO_2%	62.7	8.4	65.9	12.4	−1.95	0.07
Desat slope (%/s)	−2.6	1.3	−2.2	1.4	−1.67	0.12
Min SmO_2%	27.0	17.1	31.0	17.8	−2.31	0.04 *
½ time recovery (s)	23.1	12.0	22.5	14.3	0.42	0.68
Max SmO_2%	77.5	5.2	80.4	6.9	−2.20	0.05 *
muscle mass (%)	82.4	7.9	81.7	8.2	5.18	0.00 *
Spearfisherman (N = 8)						
Variables	**Dominant Lower Limb**		**Non-Dominant Lower Limb**		**t**	***p***
	Mean	**SD**	**Mean**	**SD**		
Mean SmO_2%	65.3	10.2	65.6	9.9	−0.40	0.70
Desat slope (%/s)	−2.4	1.2	−2.1	1.3	−1.01	0.34
Min SmO_2%	26.5	15.7	26.8	14.9	−0.20	0.85
½ time recovery (s)	34.4	22.4	34.1	14.3	0.03	0.98
Max SmO_2%	79.4	3.6	82.5	4.0	−1.56	0.16
muscle mass (%)	85.7	2.4	85.2	2.4	3.04	0.02 *

SD, standard deviation; t, test value for t-test; p, level of significance; *, marks the level of significance for $p < 0.05$.

Table 2 shows correlations between the muscle mass percentage and power outputs of the Wingate test and muscle oxygenation parameters. Of the total sample of participants, there was a significant relation for minimum power (0.67), Desat slope (−0.48), and minimum SmO_2% (−0.61) for the dominant lower limb. Similar results are presented in the group of freedivers for the dominant lower limb minimum power (0.75), power drop (0.69), Desat slope (−0.66), and minimum SmO_2% (−0.72). Spearfisherman results of the dominant muscle mass percentage relate only to peak power (−0.74). For the non-dominant lower limb results related to minimum power (0.67), minimum SmO_2% was (−0.54), and ½ time recovery was (0.49). Similarly, freedivers groups showed a significant correlation between minimum power (0.76), power drop (0.68), and minimum SmO_2% (−0.60). On the other hand, spearfisherman showed no significant correlation among the variables.

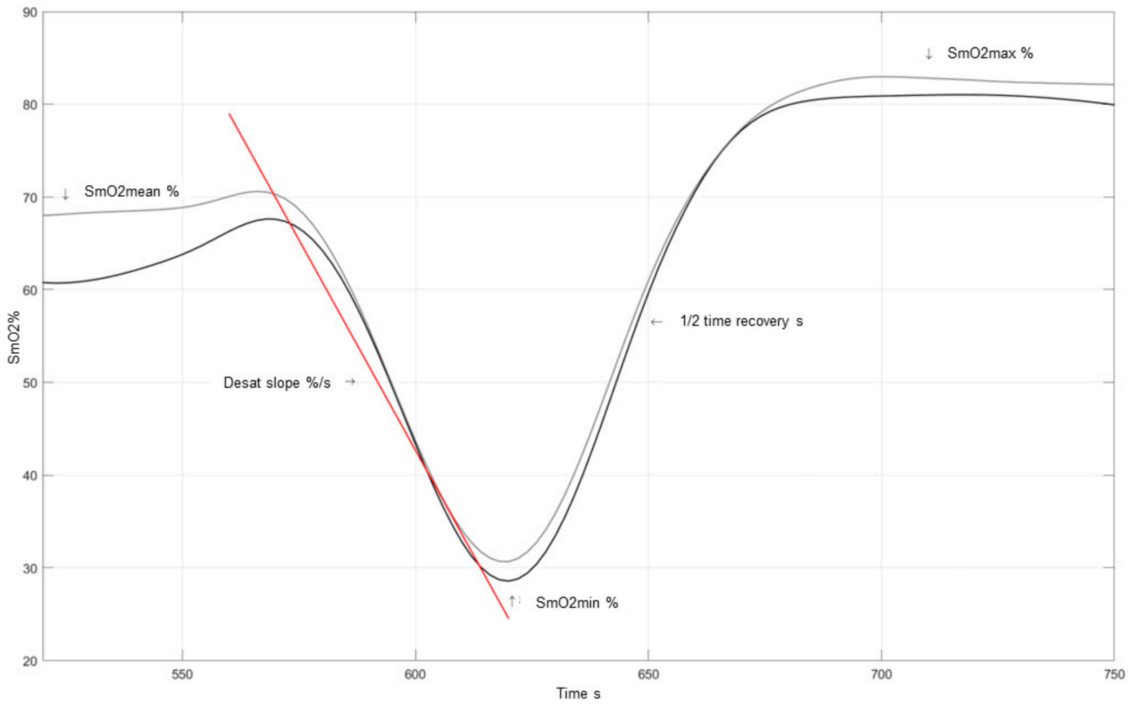

Figure 2. Graphical example of the time course of SmO_2 variables from the resting values during warm-up, test, and rest gathered from the freedivers' vastus lateralis muscle dominant lower limb (black), vastus lateralis muscle non-dominant lower limb (grey), and desaturation slope (red).

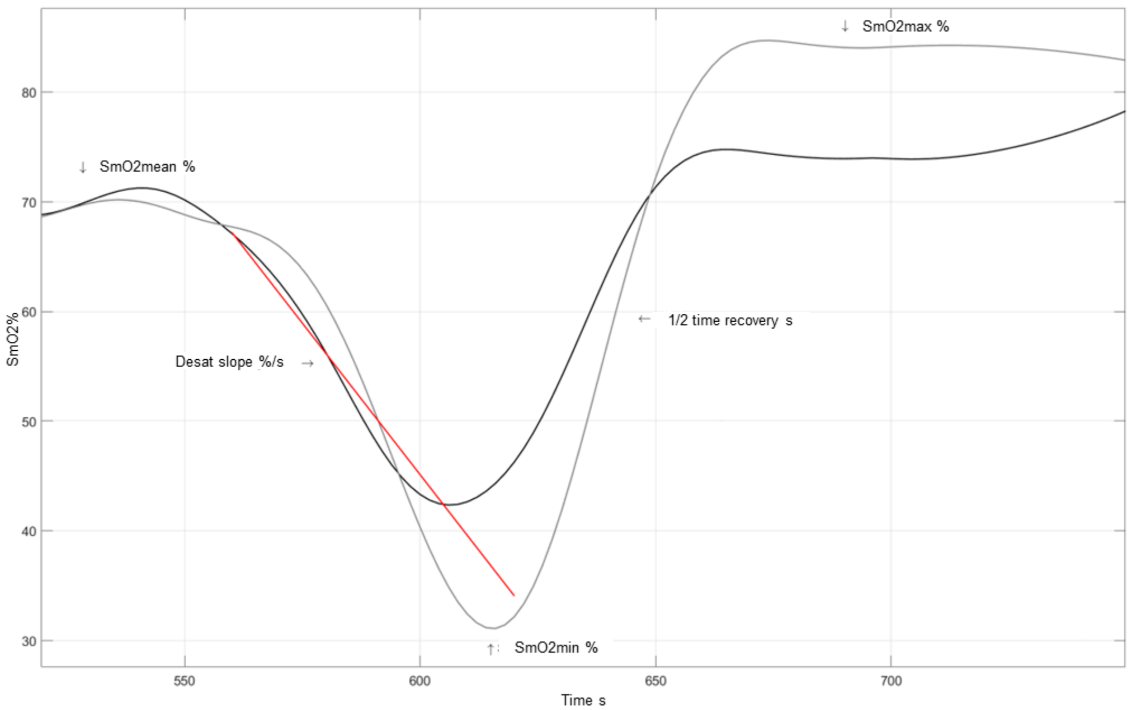

Figure 3. Graphical example of the time course of SmO_2 variables from the resting values during warm-up, test, and rest gathered from the spearfisherman's vastus lateralis muscle dominant lower limb (black), vastus lateralis muscle non-dominant lower limb (grey), and desaturation slope (red).

Table 2. Correlation between dominant and non-dominant lower limbs in local muscle oxygenation parameters and muscle mass regarding groups.

Variable	All Groups (N = 21)	Freedivers (N = 13)	Spearfisherman (N = 8)
	Dominant Lower Limb Muscle Mass (%)		
Peak power (W/kg)	0.11	0.36	−0.74 *
Average power (W/kg)	0.14	0.38	−0.70
Minimum power (W/kg)	0.67 *	0.75 *	0.60
Power drop (W)	0.35	0.69 *	0.16
Mean SmO_2%	0.11	−0.02	0.64
Desat slope (%/s)	−0.48 *	−0.66 *	0.07
Min SmO_2%	−0.61 *	−0.72 *	−0.41
½ time recovery (s)	0.29	0.37	0.06
Max SmO_2%	0.08	0.01	0.27
Variable	**All Groups (N = 21)**	**Freedivers (N = 13)**	**Spearfisherman (N = 8)**
	Non-Dominant Lower Limb Muscle Mass (%)		
Peak power (W/kg)	0.14	0.37	−0.64
Average power (W/kg)	0.17	0.40	−0.62
Minimum power (W/kg)	0.67 *	0.76 *	0.55
Power drop (W)	0.35	0.68 *	0.25
Mean SmO_2%	0.08	0.02	0.62
Desat slope (%/s)	−0.31	−0.37	−0.30
Min SmO_2%	−0.54 *	−0.60 *	−0.28
½ time recovery (s)	0.49 *	0.54	0.18
Max SmO_2%	0.02	−0.08	0.45

*, marks the level of significance for $p < 0.05$.

4. Discussion

Lower limb muscle oxygenation asymmetry was shown to influence different parameters such as injury rate [20], strength [15], performance [14], and the influence of sport [21]. However, there is a void in studies that investigate these differences for specific athlete groups (e.g., freedivers, spearfisherman). Therefore, this study aimed to determine the differences in local muscle oxygenation between the lower limbs according to the muscle mass percentage in spearfishermen and freedivers. Accordingly, we reported several important findings as follows: (1) freedivers show significant differences in oxygenation parameters between lower limb dominance according to their muscle mass; (2) correlations between oxygenation parameters and muscle mass of the lower limbs are observed for both lower limb in freedivers; and (3) lateralization in the lower limbs is more visible in freedivers than spearfisherman for differences and correlations.

4.1. Lateralization of the Lower Limbs in Muscle Oxygenation Parameters

The results showed that the freedivers group experienced significant differences in some parameters of muscle oxygenation between the lower limbs. It is demonstrated that minimal (min SmO_2) and maximal oxygen levels (max SmO_2) are lower in the region of muscles with more muscle mass. However, there is no difference between baseline oxygenation, which implies that non-dominant lower limbs have greater usage of oxygen during the test, which is connected to the max SmO_2 after the test because of the greater need for oxygen. On the other hand, the desaturation slope is similar in both lower limbs. Such results show that during a WAnT test, both dominant and non-dominant lower limbs use oxygen in the muscle at the same rate for the production of energy. Previous studies that explored the lower limb differences in muscle oxygenation mainly included ice speed skating [14,40]. According to Hettinga, Konings and Cooper [14], asymmetries in ice speed skaters are explained due to the demands of this sport (circular movements of the athlete during a race). Furthermore, these asymmetries in deoxygenation and reoxygenation during the ice speed skating race were also shown to be influential in the performance and training regimes of these athletes [40]. Hence, as freediving is considered an anaerobic sport that relies on the use of the lower limbs during a competition [24,41], these data could be valuable for the performance of freedivers.

However, looking at the group of spearfishermen, their baseline oxygen levels are similar in both lower limbs. Following this, other parameters experience the same trend of desaturation and resaturation between the limbs. Such findings could imply that freedivers show a higher impact of lateralization in the lower limbs. This lies in the fact that their dominant lower limb starts the test with lower levels of oxygen. This could be because they rely more on their more muscular lower limbs for training, which they endure. On the other hand, spearfishermen are mostly recreational and do not train specifically for diving. During an interview with our sample of spearfishermen, we concluded that most of them are involved in different training regimes that are based on recreational purposes (e.g., running, biking, CrossFit). Such implications could serve as an explanation for the aforementioned differences.

4.2. Correlations between WAnT Parameters and Limb Dominance

Correlation analysis demonstrated different relations between muscle mass and WAnT parameters for groups of participants. To be precise, freedivers had a significant correlation of muscle mass with minimal power and power drop for both dominant and non-dominant lower limbs. Such results are logical and cannot explain the difference between the lower limbs since WAnT parameters are shown as bilateral. However, it can be noticed that those participants who had higher muscle mass percentages exhibited higher values of both WAnT parameters (power drop and minimal power). Previous findings corroborate our results, demonstrating a positive correlation between power parameters and the lean mass of lower limbs during WAnT [42]. The authors of this study demonstrated that there were no significant differences between males and females. Therefore, the role of lower limb muscle mass was explained to be important in WAnT performance. On the other hand, spearfishermen do not perceive the same results as freedivers in terms of WAnT. Precisely, only the peak power of WAnT was shown to be significantly correlated with dominant lower limb muscle mass. Such findings could be explained by the variability of the muscle mass percentage, which is different in these groups. Other factors could be influential, such as the adaptation to the demands of activities in which participants are involved. Also, the long-term adaptation of BHD athletes to a low-oxygen environment could be a possible explanation.

4.3. Correlations between Muscle Oxygenation Parameters and Limb Dominance

Similarly to the correlations of WAnT, muscle oxygenation relates differently when observed through groups of participants. To be precise, freedivers exhibit a negative relation between both lower limb muscle mass and minimal oxygen level. However, the dominant lower limbs also showed a negative relation to the desaturation slope. Moreover, these relations were not found for spearfisherman. Previous studies showed the muscle oxygenation differences in the arms and lower limbs. According to Calbet et al. [43], the arms have lower extraction and capillary muscle conductance of oxygen. These findings were explained as a higher diffusing distance and higher heterogeneity in the distribution of blood flow between muscles or functional portions of the same muscle, or lower mean transit time and lower diffusing area in the arms than in the lower limbs [43]. Similarly, these explanations could be seen through findings of the influence of muscle mass on oxygenation in our study. Following the abovementioned, these results indicate that differences between muscle mass can impact the rate at which the lower limb is consuming oxygen. However, since the freedivers rely on prolonged oxygen reserves for their dives [24], the desaturation of the muscles may need to be slower. Therefore, lower muscle mass could be more important for freedivers.

4.4. Limitations and Strengths

One of the main limitations of this study is the small sample size, which means that results should be interpreted with caution and further checked in larger sample sizes. Furthermore, the TANITA scale used in the upright position may be influenced by gravity due to body fluid fluctuations. Hence, the supine method should be used in future studies. Also, the MOXY monitor did not go through the calibration process which was previously established [44]. The calibration process should be used in future studies. Moreover, one of the limitations is the fact that spearfishermen are recreational athletes, and the history of their activity is unknown. This means that the activity that they perform in their free time could potentially intervene with the results of WAnT. Also, BHD athletes perform in specific media, which could be influential to the results of dry-land tests. Both groups of participants are defined as BHD athletes, and since this is a cross-sectional comparative study, the lack of a control group could be seen as a possible limitation. This is due to the fact that long-term adaptation to diving activities may influence the results.

That being said, one of the strengths of this study is that these athletes are performing in a highly anaerobic manner. Therefore, tests like this could be influential to their performance. Also, there is a void in studies that define these symmetries in BHD athletes. Therefore, the evaluation of anaerobic capacities and lower limb symmetries can be crucial in competition and training management. In this way, coaches and athletes themselves can take immediate action to improve their sports performance.

5. Conclusions

In conclusion, the main goal of freediving is to perform the longest apnea possible, either during static or dynamic events. To perform at their best, athletes need to be fully prepared both aerobically and anaerobically for such tasks. Therefore, an examination of aerobic/anaerobic capacities should play a pivotal role in the periodization and programming of the training. Our study examined the differences in local muscle oxygenation between the lower limbs according to muscle mass percentage in spearfisherman and freedivers.

The results of this study demonstrate that freedivers had significant asymmetries between the lower limbs in muscle oxygenation parameters when observing the lower limb dominance in relation to the percentage of muscle mass. Furthermore, desaturation slop and minimal oxygenation correlate significantly with more muscular lower limbs. On the other hand, spearfishermen do not share the same results. To be precise, their oxygenation parameters do not differ between the lower limbs. These findings suggest a different adaptation to the load set upon athletes. Also, such findings could be explained by the fact that freedivers in this study are competing at the highest level, whereas spearfishermen are participating in activity recreationally.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

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