IJPHCS
Open Access: e-Journal

International Journal of Public Health and Clinical Sciences
e-ISSN : 2289-7577. Vol. 6:No. 1
January/February 2019

DIVING EXPOSURE EFFECT ON TRADITIONAL DIVERS'S QUALITY OF LIFE WITH DECOMPRESSION SICKNESS

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https://doi.org/10.32827/ijphcs.6.1.94

ABSTRACT

Background: Decompression sickness is thought to have effect on health related quality of life (HRQL), however, there is a little research in Indonesia. We measured HRQL on traditional diver with decompression sickness in Karimunjawa. The purpose of this study is to explain the effect of diving exposure on traditional diver's quality of live with decompression sickness.

Materials and Methods: This research was an observational analytic research with case-control study design. The participants were 66 volunteer traditional divers with decompression sickness. The case group (33 volunteer who had poor quality of life) while the control group (33 volunteer who had good quality of life). HRQL were measured using the SF-36 questionnaire. The data obtained from the study were analyzed using bivariate and multivariate analysis.

Result: Diving exposure variables that had been proven to affect poor quality of life were diving depth ≥ 30 meters (p = 0.014; OR = 38.410; 95% CI = 2.114 – 698.028), diving duration ≥ 2 hours (p = 0.021; OR = 9.860; 95% CI = 1.410 – 68.943), history of loss of consciousness during diving (p = 0.009; OR = 12.456, 95% CI = 1.884 – 82.363), frequency of decompression sickness history > 1 time (p = 0.020; OR = 8.834; 95% CI = 1.404 – 55.584). Diving exposure variable that unproven to affect poor quality of life was repeated dives on the same day.

Conclusion: Diving exposure variables that had been proven to affect poor quality of life on traditional diver with decompression sickness were diving depth ≥ 30 meters, diving duration ≥ 2 hours, history of loss of consciousness during diving, frequency of previous decompression sickness > 1 time.

Keywords: decompression sickness, HRQL, SF-36

1.0Introduction

Diving and hyperbaric exposure is associated with a number of well recognised acute illnesses or injure, including decompression sickness (Macdiarmid et al, 2005). Decompression sickness is caused by bubbles in blood or tissue during or after a reduction in environmental pressure (decompression) (Vann et al, 2011). A diver's blood and tissues absorb additional nitrogen (or helium) from the lungs when at deep. If a diver ascends too fast this excess gas will separate from solution and from bubbles. These bubbles produce mechanical and biochemical effects that lead to a condition known as decompression sickness. When the skin is involved, the symptoms are itsching or burning usually accompanied by a rash. Involvement of the lymphatic system produces swelling of regional lymph nodes or an extremity. Involvement of the musculoskeletal system produces pain, which in some cases can be excruciating. Bubble formation in the brain can produce blindness, dizziness, paralysis and even unconsciousness and convulsion. When the spinal cord is involved, paralysis and/or loss of feeling occur. Bubbles in the inner ear produce hearing loss and vertigo. Bubbles in the lungs can cause coughing, shortness of breath, and hypoxia, a condition referred to as the chokes. A large number of bubbles in the circulation can lead to cardiovascular collapse and death (Commander, 2017).

Decompression sickness is an occupational hazard, common among fisherman divers and caused or related with several factors (Wahab et al, 2008). Divers reporting neurological damage, psychiatric illness, forgetfulness or loss of concentration tended to have had longer diving careers and suffered decompression sickness (Macdiarmid et al, 2005; McQueen et al, 1994). Compressors traditional divers can suffer decompression sickness in paralysis and even death (Kemenkes RI, 2013a). In the U.S., U.K., and Canadian militaries between 1994 and 1997, 190 decompression sickness cases were reported (Laurens et al, 2017). The incidence of decompression sickness in Australian cave divers was estimated to be 2.8:10,000 (0.028%) (Richard, et al, 2015). The incidence of decompression sickness in American SCUBA diving were 1:2,900 dives on recreational divers, 1:280 dives on commercial divers, 1:3,770 dives on military divers, 1:270 dives on sport divers (cold water wrecks), 1:1,000 dives on dive instructors, 1:1,250 dives on sport divers (cold water) (Peter, 2006). The number of fishermen in Indonesia who show symptoms of decompression sickness was 15.3% (Kemenkes RI, 2013b). The incidence of decompression sickness in Karimunjawa was 56.1% on fishermen divers (Kartono, 2007). Rate of occurence (per dive) in operational open water dives from minutes to several hours in duration varies according to the diving population: typically 0.015% for scientific divers, 0.01 – 0.019% for recreational divers, 0.030% for US Navy divers, and 0.095% for commercial divers (Vann et al, 2011).

Quality of life is the perception of individual's situations in life in relation to their aims, expectations, and standards within the framework of their cultural and value systems (WHO, 1999). Decompression sickness occurs in a small population but is an international problem that few physicians are trained to recognise or manage. Although its manifestations are often mild, the potential for permanent injury exists in severe cases, especially if unrecognised or inadequately treated (Vann et al, 2011). Diver health score (DHS) was found to increase one unit for every 1% increase in the risk of decompression sickness. Increased risk of decompression sickness will reduce the divers's health status so that quality of life declines

(Doolette & Gorman, 2003). Among divers, neurological decompression sickness had a significant negative impact on mental component summary (MCS) health related quality of life (Macdiarmid et al, 2005). Health related quality of life (HRQL) was reduced in the study sample of divers. Having had decompression sickness during the diving career contributed significanly to the reduction in all SF-36 scales. Diving exposure in maximal depth associated with decreased health related quality of life on body pain scale, general health scale, vitality scale, social function scale, role-emotional scale, and mental health scale (Irgens et al, 2007). Divers with an incident of decompression sickness performed worse in a memory test and reported slightly more neuropsychiatric symptoms (Bast-Pettersen et al, 2015). Repeated dives on the same day, frequency of decompression sickness history, history of loss of consciousness during diving, reported lower physical component summary scores and mental component summary scores of health related quality of life (Irgens et al, 2016).

Assessing the patient’s perspective in the evaluation of the burden of disease has become common during the past decades. Self reported health related quality of life (HRQL) has been used for a number of purposes, including clinical studies and population monitoring. As a multidimensional concept reflecting the overall subjective condition of the individual, health related quality of life has been used widely either in the assessment of life quality in the general population and patients with chronic disease, or to evaluate the effect of different therapeutic modalities. The Medical Outcomes Study Short-Form General Health Survey (SF-36) is widely used and validated in medical research (Ware, 2000). Increased prevalence of some symptoms reported in the previous studies might, however, indicate a reduce health related quality of life (HRQL). Divers’s quality of lifeneeds to be measured using SF-36 to investigate the effect of diving exposure on present HRQL.

In Karimunjawa, Central Java, Indonesia still has traditional divers. Based on data from Karimunjawa Primary Health Centre there was 140 cases and 14 deaths caused hyperbaric incident (2003 until April 2017). Based on these reasons, research needs tobe done. The purpose of this study is to explain the effect of diving exposure on traditional divers’s quality of life with decompression sickness, as assessed by the SF-36.

2.0 Materials and Methods

The type of research was an observational analytic research with case-control study design. Study population in this research were traditional divers with decompression sickness in Karimunjawa, Central Java, Indonesia. The participants were 66 volunteer traditional divers with decompression sickness, were obtained by purposive sampling technique. The participants who had poor quality of life were included in the case group (n = 33). While participants who had good quality of life composed the control group (n = 33). HRQL were measured using the SF-36 questionnaire. Poor quality of life was measured using SF-36 questionnaire showing 0 – 50 score. Good quality of life was measured using SF-36 questionnaire showing 51 – 100 score (Modersitzki, 2014). The dependent variable was traditional divers’squality of life with decompression sickness. The independent variables were diving depth, diving duration, repeated dives on the same day, history of loss of consciousness during diving, frequency of decompression sickness history.

The study was conducted using primary and secondary data of traditional divers with decompression sickness. We collected primary data via face to face interviews with a questionnaire form about diving exposure and SF-36 quality of life scale. The questionnaire form consisted questions regarding diver's diving exposure (diving depth, diving duration, repeated dives on the same day, history of loss of consciousness during diving, frequency of previous decompression sickness). The SF-36 questionnaire consists of 36 items covering eight distinct health status concepts (physical functioning, physicalrole limitations, bodily pain, general health, vitality, social functioning, emotionalrole limitations, mental health) which can be combined into a physical component summary (PCS) and mental component summary (MCS), and one item measuring self reported health transition (Ware et al, 2000; Zadeh & Kalantar, 2000). The SF-36 questionnaire can be considered for assessment of HRQL. It was demonstrated that the SF-36 questionnaire has had adequate reliability and validity in general population and patients with various diseases, including in Indonesia (Ware et al, 2000; De Haan, 2002; Ware, 2000; Salim, 2015; Rachmawati et al, 2014). The secondary data was obatined from medical record data of decompression sickness patients in Navy Marine Health Institution (LAKESLA) Drs. Med. R. Rijadi., Phys Surabaya and Karimunjawa Primary Health Centre in 2010 until April 2017.

This study was reviewed and approved by ethics committee in Semarang, Central Java, Indonesia: Ethical Committee of Health Research (KEPK) Faculty of Medicine, Diponegoro University and dr.Kariadi Hospital Semarang. The participants were informed about our aims in the study and their informed consent was obtained prior to administration of the questionnaire.

Statistical analysis were carried out using bivariate and multivariate analysis. Chi-square tests was used to identify the effects between the independent variable and the dependent variable. Multivariate logistic regression analysis were used to identify significant predictors of poor health related quality of life (HRQL) in the study population (both cases and controls group). The independent variables in the mutivariate logistic regression analysis were selected based on results from earlier chi-square tests, variables that generate value ($p < 0.25$) were included in the regression model. To test if the effects of predictors of change in our dependent vaiable were significantly different for cases and controls, interaction terms involving the cases and controls dichotomy and each of the predictors were entered one pair at a time, while retaining main effects in the model. The level of significance was set at 0.05.

3.0 Result

3.1 Bivariate analysis in diving exposure on case and control group

Bivariate analysis in diving exposure on case and control group were presented in Table 1 below.

Table 1: Bivariate analysis in diving exposure on case and control group (N = 66)

Diving exposure	**Case (n = 33)**		**Control (n = 33)**		**P**	**OR**	**95% CI**
	n (%)		**n (%)**				
Diving depth							
≥ 30 meters	29	(87.9)	15	(45.5)	0.001	8.700	2.493 – 30.364
< 30 meters	4	(12.1)	18	(54.5)			
Diving duration							
≥ 2 hours	21	(63.6)	13	(39.4)	0.085	2.692	0.995 – 7.284
< 2 hours	12	(36.4)	20	(60.6)			
Repeated dives on the same day							
Yes	20	(60.6)	8	(24.2)	0.006	4.808	1.667 – 13.862
No	13	(39.4)	25	(75.8)			
History of loss of consciousness during diving							
Yes	18	(54.5)	3	(9.1)	0.000	12.000	3.048 – 47.244
No	15	(45.5)	30	(90.9)			
Frequency of previous decompression sickness							
>1 time	19	(57.6)	11	(33.3)	0.084	2.714	0.998 – 7.380
1 time	14	(42.4)	22	(66.7)			

According Table 1, statistically significant differences in diving deep (p = 0.001), repeated dives on the same day (p = 0.006), history of loss of consciousness during diving (p < 0.001) on case and control group, but statistically no significant differences in diving duration and frequency of previous decompression sickness on case and control group (p > 0.05).

3.2 Bivariate analysis in diving exposure on physical component summary (PCS)

Bivariate analysis in diving exposure on physical component summary (PCS) were presented in Table 2 below.

Table2: Bivariate analysis in diving exposure on physical component summary (PCS)

Diving exposure	Physical component summary				P	OR	95% CI
	Poor n (%)		Good n (%)				
Diving depth							
≥ 30 meters	28	(63.6)	16	(36.4)	0.004	5.950	1.845 – 19.193
< 30 meters	5	(22.7)	17	(77.3)			
Diving duration							
≥ 2 hours	21	(61.8)	13	(38.2)	0.085	2.692	0.995 – 7.284
< 2 hours	12	(37.5)	20	(62.5)			
Repeated dives on the same day							
Yes	21	(75.0)	7	(25.0)	0.001	6.500	2.174 – 19.435
No	12	(31.6)	26	(68.4)			
History of loss of consciousness during diving							
Yes	18	(85.7)	3	(14.3)	0.000	12.000	3.048 – 47.244
No	15	(33.3)	30	(66.7)			
Frequency of previous decompression sickness							
> 1 time	19	(63.3)	11	(36.7)	0.084	2.714	0.998 – 7.380
1 time	14	(38.9)	22	(61.1)			

According Table 2, statistically significant differences in diving deep (p = 0.004), repeated dives on the same day (p = 0.001), history of loss of consciousness during diving (p < 0.001) on physical component summary, but statistically no significant differences in diving duration and frequency of previous decompression sickness on physical component summary (p > 0.05).

3.3 Bivariate analysis in diving exposure on mental component summary (MCS)

Bivariate analysis in diving exposure on mental component summary (MCS) were presented in Table 3 below.

Table3: Bivariate analysis in diving exposure on mental component summary (MCS)

Diving exposure	Mental component summary				P	OR	95% CI
	Poor n (%)		Good n (%)				
Diving depth							
≥ 30 meters	7	(15.9)	37	(84.1)	0.364	1.892	0.359 – 9.979
< 30 meters	2	(9.1)	20	(90.9)			
Diving duration							
≥ 2 hours	3	(8.8)	31	(91.2)	0.208	0.419	0.095 – 1.843
< 2 hours	6	(18.8)	26	(81.2)			
Repeated dives on the same day							
Yes	5	(17.9)	23	(82.1)	0.308	1.848	0.448 – 7.624
No	4	(10.5)	34	(89.5)			
History of loss of consciousness during diving							
Yes	5	(23.8)	16	(76.2)	0.106	3.203	0.762 – 13.467
No	4	(8.9)	41	(91.1)			
Frequency of previous decompression sickness							
> 1 time	6	(20.0)	24	(80.0)	0.155	2.750	0.625 – 12.108
1 time	3	(8.3)	33	(91.7)			

According Table 3, statistically no significant differences in diving deep, diving duration, repeated dives on the same day, history of loss of consciousness during diving, and frequency of previous decompression sickness on mental component summary ($p > 0.05$).

3.4 Multivariate analysis result

Multivariate analysis using multivariate logistic regression (MLR) analysis were used to identify significant predictors of poor health related quality of life (HRQL) in the study population (both cases and controls group), and calculate odds ratio (OR) presented with 95% confidence interval (CI). A P-value < 0.05 was considered statistically significant. Multivariate analysis result statistically significant were presented in Table 4 below.

Table4: Multivariate analysis result statistically significant(P-value < 0.05)

Diving exposure	B	P	OR	95% CI
Diving depth ≥ 30 meters	3.648	0.014	38.410	2.114 – 698.028
Diving duration ≥ 2 hours	2.289	0.021	9.860	1.410 – 68.943
Have a history of loss of consciousness during diving	2.522	0.009	12.456	1.884 – 82.363
Frequency of previous decompression sickness > 1 time	2.179	0.020	8.834	1.404 – 55.584
Constant	-7.629			

According Table 4, diving depth ≥ 30 meters, diving duration ≥ 2 hours, have a history of loss of consciousness during diving, and frequency of previous decompression sickness > 1 time, statistically worth to mantain in the model. Logistic regression equation:

$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4$

y = -7.629 + (3.648 x diving depth ≥ 30 meters) + (2.289 x diving duration ≥ 2 hours) + (2.522 x have a history of loss of consciousness during diving) + (2.179 x frequency of previous decompression sickness > 1 time).

y = -7.629 + (3.648 x 1) + (2.289 x 1) + (2.522 x 1) + (2.179 x 1) = 3.009

The probability of a poor quality of life occurence can be calculated by the following equation:

$$P = \frac{1}{1+e^{-(\alpha+\beta 1x1+\beta 2x2+\beta 3x3+\beta 4x4)}} x100\% = \frac{1}{1+\exp(-y)} \text{ x } 100\% = \frac{1}{1+\exp(-3.009)} \text{ x } 100\% = 95.29\%$$

4.0 Discussion

Multivariate analysis using multivariate logistic regression (MLR) analyzed candidate variables simultaneously. Multivariate analysis result, variables that had been proven to affect on poor traditional divers's quality of life with decompression sickness were diving depth ≥ 30 meters (p = 0.014; OR = 38.410), diving duration ≥ 2 hours (p = 0.021; OR = 9.860), have a history of loss of consciousness during diving (p = 0.009; OR = 12.456), frequency of previous decompression sickness > 1 time (p = 0.020; OR = 8.834).

Diving depth ≥ 30 meters had been proven to affect on poor traditional divers's quality of life with decompression sickness, when analyzing using multivariate analysis statistically siginificant (p = 0.014, OR = 38.410, 95% CI = 2.114 – 698.028) (table 4), therefore diving depth ≥ 30 meters had a risk 38.41 times more than diving depth < 30 meters to occured poor quality of life. Diving depth ≥ 30 meters also affected physical component summary/PCS (p = 0.004) (table 2). Deeper dives were associated with more risk. The accident rate for dives between 30 – 61 m (101 – 200 ft) was 0.54%. This was in line with the research that diving depth ≥ 30 meters was a decompression sickness risk factor (Duke et al, 2017). A diver deeper the dive then greater the atmospheric pressure received. The increased diving depth, the risk of decompression sickness was greater (Mitchell, 2005a). During a dive, air is breathed at increased pressure, and therefore more of the nitrogen molecules from the air can dissolve into the blood. The nitrogen enters the blood in the lung capillary bed, and after passing through the left heart, is distributed to the tissue via the arteries. In the capillary beds of the head and body, nitrogen leaves the blood and diffuses into tissues. The deeper the dive, the faster the nitrogen is taken up from the air we breathe. During the subsequent ascent, pressure falls and less nitrogen can remain dissolved in the tissues. As pressure falls the nitrogen diffuses out of tissues and into the venous blood in the capillary beds of the head and body. It is carried in the veins back to the lungs for elimination. Ideally, this elimination process occurs fast enough to dissipate the nitrogen molecules without bubble formation. However, in tissues that cannot get rid of their nitrogen very quickly, the pressure of dissolved nitrogen will exceed the ambient (surrounding) pressure some point during the ascent (a process commonly referred to as supersaturation), and the molecules of dissolved nitrogen may not be able to resist the physical stimulus to form a bubble (Mitchell, 2005b). Increased risk of decompression sickness will reduce divers's health status, so that quality of life declines (Doolette & Gorman, 2003). Diving exposure in maximal depth associated with decreased health related quality of life on body pain scale, general health scale, vitality scale, social function scale, role-emotional scale, and mental health scale (Irgens et al, 2007).

Diving duration $\geq$ 2 hours had been proven to affect on poor traditional divers's quality of life with decompression sickness, when analyzing using multivariate analysis statistically siginificant ($p = 0.021$, OR = 9.860, 95% CI = 1.410 – 68.943) (table 4), therefore diving duration $\geq$ 2 hours had a risk 9.86 times more then diving duration < 2 hours to occured poor quality of life. This was in line with the research that diving duration $\geq$ 2 hours was a decompression sickness risk factor (Duke et al, 2017). The longer the dive, the more time the nitrogen has to accumulate in the tissues (Mitchell, 2005b). Increased risk of decompression sickness will reduce divers's health status, so that quality of life declines (Doolette & Gorman, 2003).

Multivariate analysis result, history of loss of consciousness during diving had been proven to affect on poor traditional divers's quality of life with decompression sickness, statistically siginificant ($p = 0.009$, OR = 12.456, 95% CI = 1.884 – 82.363) (table 4), therefore had a history of loss of consciousness during divinghad a risk 12.456 times more than no history of loss of consciousness during diving to occured poor quality of life. History of loss of consciousness during diving also affected physical component summary/PCS ($p < 0.001$) (table 2). This was in line with the research that divers having experienced loss of consciousness due to gas cut had lower SF-36 sub-scores then the rest of the diving population (Sundal et al, 2013). Health related physical and mental component summary scores were lower in divers with history of loss of consciousness during diving (Irgens et al, 2016). Loss of consciousness on diver, during diving or after diving happens for many reasons. Environmental conditions, diving equipmet, diving techniques, and diver health conditions can cause divers to loss of consciousness. Exposure to cold is often cited as risk factor for decompression sickness. Exposure to cold caused the change in the diver's temperature during the dive. If uptake of nitrogen occurs while the diver is warm and blood flow to the peripheries is good, and elimination occurs while the diver is cool and peripheral blood flow has reduced, then nitrogen elimination will be slower (than uptake) and the risk of decompression sickness increased (Mitchell, 2005a). When bubbles become trapped in the blood vessels of the brain we usually see rapid onset of dramatic neurological symptoms such as loss of consciousness and decompression sickness can occured (Mitchell, 2005c). Increased risk of decompression sickness will reduce divers's health status, so that quality of life declines (Doolette & Gorman, 2003).

Multivariate analysis result, frequency of previous decompression sickness > 1 time had been proven to affect on poor traditional divers's quality of life with decompression sickness, statistically siginificant ($p = 0.020$, OR = 8.834, 95% CI = 1.404 – 55.584) (table 4), therefore frequency of previous decompression sickness > 1 time had a risk 8.834 times more than frequency of previous decompression sickness 1 time to occured poor quality of life. This was in line with the research that previous neurologic dekompression sickness had lower health related quality of life for mental component summary (MCS) (Macdiarmid et al, 2005). Reduced SF-36 scores were seen from all scales among divers who reported previous decompression sickness compared to those without decompression sickness (Irgens et al, 2007). Health related physical and mental component summary scores were lower in divers with previous neurologic dekompression sickness (Irgens et al, 2016). Previous decompression sickness may predispose to another episode by reducing the body's ability to compensate for any subsequent bubble formation (Mitchell, 2005a). Divers's health status and quality of life will reduce if risk of decompression sickness increased (Doolette & Gorman, 2003).

Multivariate analysis result, repeated dives on the same day had been unproven to affect on poor traditional divers's quality of life with decompression sickness, statistically no siginificant ($p > 0.05$). This was not in line with the research that health related physical and mental component summary scores were lower in divers with repeated dives on the same day (Irgens et al, 2016). Repetitive dives are considered to increase risk of decompression sickness. The suggested basis for increased risk in closely spaced sequential dives is bubble formation from dissolved inert gas after the first ascent to the surface. During any subsequent dive, these bubble may affect inert gas kinetics ad may at as seeds for larger bubbles (Mitchell, 2005a).

The results of the probability calculation of poor quality of life occurence indicated that traditional divers's with decompression sickness that diving depth ≥ 30 meters, diving duration ≥ 2 hours, had a history of loss of consciousness during diving, frequency of previous decompression sickness > 1 time had probability 95.29% to occurred poor quality of life.

5.0Conclusion and recommendation

The factors affecting poor quality of life on traditional diver with decompression sickness in Karimunjawa were diving depth ≥ 30 meters, diving duration ≥ 2 hours, had a history of loss of consciousness during diving, frequency of previous decompression sickness > 1 time.

Future research should focus on an observational analytic research with experiment study design on providing educational information consultation, periodict health examination, diving plan preparation in improving the traditional divers's quality of life with decompression sickness.

Acknowledgement

We thank to all the people who have helped this research and publication process.

Declaration

The authors declare that they have no conflict of interest regarding publication of this article.

Authors contribution

Author 1: information gathering, preparation and editing of manuscript
Author 2: review of manuscript
Author 3: review of manuscript

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