Original Article

JER

http://dx.doi.org/10.12965/jer.150252

Journal of Exercise Rehabilitation 2015;11(6):331-336

Injury survey in scuba divers of British Sub-Aqua Club: A retrospective study

Gwang-Suk Hyun[1], Yong-Seok Jee[2], Jung-Min Park[1], Nam-Heung Cho[3], Jun-Youl Cha[1,*]

[1]Department of Physical Education, Chungnam National University, Daejeon, Korea
[2]Department of Physical Activity Design, Hanseo University, Seosan, Korea
[3]Department of Physical Education, Yonsei University, Seoul, Korea

Scuba diving itself is generally known as a safe sports. However, various injury accidents can happen, and the incidences vary depending on divers' education grade levels about the risks. Therefore, the study set out to identify and analyze the causes and patterns of injuries depending on the divers' safety education grade levels through a questionnaire survey targeting ocean divers (n=12), sports divers (n=16), and dive leaders (n=15), all of whom belong to the British Sub-Aqua Club. After conducting a frequency analysis on the collected questionnaires, the conclusions are made as follows. First, in terms of diving depth, the most frequent diving depth was 15–20 m among ocean divers, 20–25 m among sports divers, and 15–20 m in case of dive leaders. Second, with regard to the causes of injuries, the most frequently answered causes are 'overtension' and 'low skill' among ocean divers; 'low skill' among sports divers; 'overaction' among dive leaders. Third, in terms of injury patterns, the most frequently answered injury patterns are 'ear' injuries among ocean divers; 'ankle' injuries among sports divers; 'ankle' and 'calf' injuries among dive leaders. Fourth, with regard to who performed first-aid when an injury accident happened, the most frequent answers are 'instructor' among ocean divers; 'instructor' and 'self' among sports divers; 'self' among dive leaders. We might suggest that more efforts need to be made to improve divers' low dependence on specialists for treatment and consultation so that we can prevent an injury from leading to the second injury accident.

Keywords: Scuba, Injury, Sea depth, Lack of practice

INTRODUCTION

The participation in physical activities through various leisure sports allows people to relieve stress from their everyday jobs and to enhance the quality of their lives. In the modern society, people have more spare time, and therefore, as an increasing number of people is participating in leisure sports, scuba diving is enjoying the limelight.

Scuba diving is becoming popular and the number of scuba divers is increasing, as it allows a diver to see maritime plants and animals at a close range. Scuba diving is an adventure open to anyone aged 12 or over and with our worldwide network of clubs and centers providing accessible, affordable scuba diving lessons, it's never been easier to learn to dive (http://www.bsac.com). Scuba diving may be performed for a number of reasons, both personal and professional. Recreational diving is performed purely for enjoyment and has a number of distinct technical disciplines to increase interest underwater, such as cave diving, wreck diving, ice diving and deep diving.

Scuba diving itself is generally known as a safe sports but involves potential risks that various injury accidents can happen during scuba diving (Elliott, 2000; Morgan, 1995), and in fact, divers often suffer minor and serious injuries. As scuba diving is a leisure sports in which a diver breathes through a self-contained underwater breathing apparatus to observe the underwater world. As various dangerous situations can occur from the preparation stage to the final stage, divers must always abide by the rules and regulations of the diving manual offered by the diving associations. Despite that, various injury accidents are reported. Therefore, this study set out to analyze the pattern, frequency and cause

*Corresponding author: Jun-Youl Cha
Department of Physical Education, Chungnam National University, 99 Daehak-ro, Yuseong-gu, Daejeon 34134, Korea
Tel: +82-63-450-7655, Fax: +82-42-821-8897, E-mail: roksfcha@hanmail.net
Received: October 1, 2015 / Accepted: October 11, 2015

pISSN 2288-176X
eISSN 2288-1778

Table 1. Demographic data for the divers

Group	Age (yr)	Height (cm)	Weight (kg)	Carrier (mo)
Ocean diver (n=12)	32.42±8.55	173.00±8.47	70.00±8.59	26.42±32.77
Sports diver (n=16)	28.94±4.75	168.31±8.20	61.69±11.24	33.88±19.41
Dive leader(n=15)	36.93±7.91	176.87±8.19	76.87±16.71	130.00±101.81
Total (n=43)	32.70±7.74	172.60±8.88	69.30±14.15	65.33±78.57

Values are presented as mean±standard deviation.

of injury form scuba diving and to provide guidelines for a safe and pleasant diving experience by preventing injury accidents.

MATERIALS AND METHODS

Subjects

The study participants are the members of British Sub-Aqua Club (BSAC) KOREA, The samples were collected from a total 43 scuba divers, who were classified into ocean diver (n=12; 9 males, 3 females), sports diver (n=16; 7 males, 9 females), dive leader (n=15; 12 males, 3 females) using the Stratified Cluster Random Sampling. For reference, ocean divers are those licensed holders who completed a course for teaching how to perform diving without others' help. Sports divers are those licensed holders who had diving experiences in special environments more than 5 times after the acquisition of ocean diver licenses and who are able to give help to other divers. Lastly, Lead divers are those licensed holders who had diving experiences in various maritime underwater environments more than 20 times after the acquisition of sports diver licenses and who have responsibility and leadership enough to perform an open water diving training. The demographic characteristics of the study participants are summarized as seen in Table 1.

Study tool

In this study, a research tool that was used to analyze the pattern, frequency and cause of injury from scuba diving was a questionnaire, and Cronbach α was calculated from the content of the questionnaire to verify the reliability. The reliability of the questionnaire used by this study was estimated at Cronbach α=0.78.

Data processing

After collecting the questionnaires designed for an analysis of the pattern, frequency and cause of injury from scuba diving, each of them was entered and stored into a database by entry, which was later computerized according to analysis purposes. All data is expressed in the mean values and standard deviations, and the frequency analysis was used as an analysis method, and the verification was performed at a significance level of $P<0.05$.

RESULTS

For analysis of pattern, frequency and cause of injury from scuba diving, forty three divers' groups including ocean diver, sports diver and dive leader participated by returning completed questionnaires.

Purpose of scuba diving among groups

To investigate the purposes of scuba diving among groups, we selected items composed of Table 2 and analyzed below.

Table 2 describes the purpose of scuba diving according to group. In ocean diver group, the main purpose was 'hobby' (58.3%), which was followed by 'education' (41.7%). Most of sports divers went scuba diving as a hobby (81.3%). Beyond that, there were 'education' (12.5%) and 'destress' (6.3%) as the purpose for scuba diving in sports diver group. In dive leader group, most of them engaged in scuba diving as 'job' (60.0%) and 'hobby' followed it (40.0%).

Diving depths among groups

To investigate the diving depths among groups, we selected items composed of Table 3 and analyzed below.

Table 3 shows the diving depths in each group. Eight ocean divers (66.7%) reported that they dived from 15 to 20 m in depth, which is recommended as the maximum depth for safety (Richardson et al., 2008). The others dived under 15 m in depth. Most of sport divers dived at the depth of '20–25 m' (37.5%) and '25–30 m' (31.3%). Two sport divers (12.5%) reported over 30 m as their diving depth. In dive leader group, most of dive leaders (33.3%) dived from 15 to 20 m in depth, but their diving depths were evenly distributed over 15 m.

Causes of diving-related injuries

To investigate the causes of diving-related injuries among

http://dx.doi.org/10.12965/jer.150252

Table 2. Purposes of scuba diving in each group (n=43)

Group	Purpose	Frequency	Percentage
Ocean diver (n=12)	Job	0	0
	Hobby	7	58.3
	Friendship	0	0
	Destress	0	0
	Education	5	41.7
Sports diver (n=16)	Job	0	0
	Hobby	13	81.3
	Friendship	0	0
	Destress	1	6.3
	Education	2	12.5
Dive leader (n=15)	Job	9	60.0
	Hobby	6	40.0
	Friendship	0	0
	Destress	0	0
	Education	0	0

Table 3. Diving depths in each group (n=43)

Group	Depth (m)	Frequency	Percentage
Ocean diver (n=12)	<5	1	8.3
	5–10	1	8.3
	10–15	2	16.7
	15–20	8	66.7
	20–25	0	0
	25–30	0	0
	>30	0	0
Sports diver (n=16)	<5	0	0
	5–10	0	0
	10–15	1	6.3
	15–20	2	12.5
	20–25	6	37.5
	25–30	5	31.3
	>30	2	12.5
Dive leader (n=15)	<5	0	0
	5–10	1	6.7
	10–15	0	0
	15–20	5	33.3
	20–25	3	20.0
	25–30	2	13.3
	>30	4	26.7

groups, we selected items composed of Table 4 and analyzed below.

The causes of diving-related injuries were categorized into five items: 'no warm-up', 'overtension', 'low skill', 'overaction', and 'lack of practice'. In ocean diver group and sport diver group, 'overtension' (33.3% and 31.3%, respectively) and 'low skill' (33.3% and 37.5%, respectively) were reported as the main cause of diving-related injury. As other causes, 'overaction' (25.0%) and 'lack of practice' (8.3%) were presented in ocean diver group. In sports diver group, 'lack of practice' (18.8%) and 'overaction' (12.5%) followed the main causes. On the other hand, dive leaders reported 'overaction' as the main cause of injury (40.0%), which was followed by 'low skill' (26.7%), 'overtension' (13.3%), and 'lack of practice' (13.3%).

Table 4. Causes of diving-related injuries in each group (n=43)

Group	Injury cause	Frequency	Percentage
Ocean diver (n=12)	No warm-up	0	0
	Overtension	4	33.3
	Low skill	4	33.3
	Overaction	3	25.0
	Lack of practice	1	8.3
Sports diver (n=16)	No warm-up	0	0
	Overtension	5	31.3
	Low skill	6	37.5
	Overaction	2	12.5
	Lack of practice	3	18.8
Dive leader (n=15)	No warm-up	1	6.7
	Overtension	2	13.3
	Low skill	4	26.7
	Overaction	6	40.0
	Lack of practice	2	13.3

Table 5. Diving-related head and face injuries in each group (n=43)

Group	Part	Frequency	Percentage
Ocean diver (n=12)	Head	0	0
	Eye	0	0
	Nose	1	8.3
	Ear	7	58.3
	Nothing	4	33.3
Sports diver (n=16)	Head	1	6.3
	Eye	1	6.3
	Nose	4	25.0
	Ear	2	12.5
	Nothing	8	50.0
Dive leader (n=15)	Head	0	0
	Eye	1	6.7
	Nose	2	13.3
	Ear	2	13.3
	Nothing	10	66.7

Diving-related head and face injuries

To investigate the diving-related head and face injuries among groups, we selected items composed of Table 5 and analyzed below.

In this study, we investigated the diving-related injuries in each group according to body parts. Table 6 presents the diving-related head and face injuries in each group. In ocean diver group, seven divers (58.3%) reported ear injury caused by scuba-diving, which was followed by nose injury (8.3%). Nose injury was reported by sports divers (25.0%) as the main head and face injury, and ear in-

Table 6. Diving-related upper body injuries in each group (n=43)

Group	Part	Frequency	Percentage
Ocean diver (n=12)	Chest	2	16.7
	Abdomen	0	0
	Waist	2	16.7
	Nothing	8	66.7
Sports diver (n=16)	Chest	2	12.5
	Abdomen	0	0
	Waist	3	18.8
	Nothing	11	68.8
Dive leader (n=15)	Chest	1	6.7
	Abdomen	0	0
	Waist	1	6.7
	Nothing	13	86.7

Table 7. Diving-related upper extremity injuries in each group (n=43)

Group	Part	Frequency	Percentage
Ocean diver (n=12)	Shoulder	3	25.0
	Elbow	0	0
	Wrist	1	8.3
	Finger	0	0
	Nothing	8	66.7
Sports diver (n=16)	Shoulder	5	31.3
	Elbow	0	0
	Wrist	0	0
	Finger	5	31.3
	Nothing	6	37.5
Dive leader (n=15)	Shoulder	1	6.7
	Elbow	1	6.7
	Wrist	0	0
	Finger	2	13.3
	Nothing	11	73.3

jury (12.5%) followed. Similarly, nose and ear injury (13.3% and 13.3%, respectively) were reported by dive leasers as the main injury in the head and face. As expected, dive leaders reported the least head and face injury.

Diving-related upper body injuries

To investigate the diving-related upper body injuries among groups, we selected items composed of Table 6 and analyzed below.

Table 6 describes the diving-related upper body injuries in each group. Most divers of three groups have experienced the injuries in the chest and waist. In ocean diver group, two divers (16.7%) reported the chest injury, and another two divers (16.7%) reported the waist injury. Similarly, two sports divers (12.5%) reported the chest injury, and another three divers (18.8%) reported the waist injury. In dive leader group, two divers reported the chest injury and waist injury, respectively (6.7% and 6.7%, respectively).

Table 8. Diving-related lower extremity injuries in each group (n=43)

Group	Part	Frequency	Percentage
Ocean diver (n=12)	Hip	0	0
	Thigh	0	0
	Knee	4	33.3
	Calf	0	0
	Nothing	8	66.7
Sports diver (n=16)	Hip	0	0
	Thigh	0	0
	Knee	5	31.3
	Calf	3	18.8
	Nothing	8	50.0
Dive leader (n=15)	Hip	0	0
	Thigh	1	6.7
	Knee	1	6.7
	Calf	3	20.0
	Nothing	10	66.7

Diving-related upper extremity injuries

To investigate the diving-related upper extremity injuries among groups, we selected items composed of Table 7 and analyzed below.

In the upper extremity parts, the shoulder was the main lesion site in ocean diver group and sports diver group (25.0% and 31.3%, respectively). The finger (31.3%) was equally reported as the main injury site in sport diver group, and the wrist (8.3%) was also reported in ocean diver group. On the other hand, divers in dive leader group reported more various injury sites. Specifically, the shoulder, elbow, and finger were presented as the injury site in the dive leader group (6.7%, 3.7%, and 13.3%, respectively).

Diving-related lower extremity injuries

To investigate the diving-related lower extremity injuries among groups, we selected items composed of Table 8 and analyzed below.

Table 8 shows the diving-related lower extremity injuries in each group. In ocean diver group, the knee injury (33.3%) was only reported. With the knee injury (31.3%) as the main injury, the calf injury (18.8%) was also reported in sports diver group. Contrary to the lower extremity injury in ocean diver group and sports diver group, divers in dive leader group reported the calf as the main lesion site in the lower extremity part (20.0%). They also reported the thigh injury (6.7%) and knee injury (6.7%).

Diving-related feet injuries

To investigate the diving-related feet injuries among groups, we selected items composed of Table 9 and analyzed below.

Table 9 presents the diving-related feet injuries in each group.

http://dx.doi.org/10.12965/jer.150252

Table 9. Diving-related feet injuries in each group (n=43)

Group	Part	Frequency	Percentage
Ocean diver (n=12)	Ankle	2	16.7
	Instep	0	0
	Toes	0	0
	Achilles tendon	2	16.7
	Nothing	8	66.7
Sports diver (n=16)	Ankle	6	37.5
	Instep	1	6.3
	Toes	0	0
	Achilles tendon	2	12.5
	Nothing	7	43.8
Dive leader (n=15)	Ankle	3	20.0
	Instep	0	0
	Toes	0	0
	Achilles tendon	2	13.3
	Nothing	10	66.7

Table 10. Person in charge of emergency treatment (n=43)

Group	Personnel action	Frequency	Percentage
Ocean diver (n=12)	Peer	0	0
	Instructor	5	41.7
	Self	3	25.0
	Hospital	1	8.3
	Nothing	3	25.0
Sports diver (n=16)	Peer	1	6.3
	Instructor	5	31.3
	Self	5	31.3
	Hospital	1	6.3
	Nothing	4	25.0
Dive leader (n=15)	Peer	0	0
	Instructor	1	6.7
	Self	7	46.7
	Hospital	1	6.7
	Nothing	6	40.0

The main lesion sites were the ankle and Achilles tendon. Specifically, the ankle (16.7%) and Achilles tendon (16.7%) were equally reported the injury site in ocean diver group. In sports diver group, six divers (37.5%) reported the ankle injury, and others experienced the instep injury (6.3%) and Achilles tendon injury (12.5%). Similarly, divers in dive leader reported the ankle injury (20.0%) and Achilles tendon injury (13.3%).

Person in charge of emergency treatment

To investigate the person in charge of emergency treatment among groups, we selected items composed of Table 10 and analyzed below.

We investigated who was in charge of treatment in an emergency (Table 10). In both ocean diver and sport diver groups, an instructor took emergency treatment (41.7% and 31.3%, respectively). Five sports divers (31.3%) also reported to treat themselves. Similarly, divers in dive leader group took emergency treatment by themselves (46.7%). In most cases, diving-related injury in ocean diver, sports diver and dive leader groups was rarely treated in the hospital (8.3%, 6.3%, and 6.7%, respectively).

DISCUSSION

This study conducted a questionnaire survey targeting a total of 43 scuba divers, who were classified into three groups according to their education grade levels ocean divers, sports divers, and dive leaders and the analysis results of injury patterns, incidences, causes, etc. are as follows. Among the divers who participated in the study, ocean divers chose 'hobby' and 'education' as their main diving purposes. An overwhelming majority of sports divers said they do scuba diving for 'hobby'. in case of dive leaders, 'job' and 'hobby' took up the highest percentages of the entire responses.

In terms of the most frequent diving depths, the water depth of '15–20 m' took up the highest percentage at 66% among ocean divers; in terms of sports divers, '20–25 m' (37%) and '25–30 m' (31%) are the most frequently experienced diving depths; among dive leaders, the frequent diving depths are in the order of '15–20 m' (33%), '30 m or deeper' (26%), '20–25 m' (20%) and '25–30 m' (13%). In terms of injury causes, 'overtension' and 'low skill' equally accounted for 33% of the entire responses among ocean divers, followed by 'overaction' (25%); among sports divers, 'low skill' took up the highest percentage at 37%, followed by 'overtension' (31%) and 'lack of practice' (18%); among dive leaders, 'overaction' accounted for the highest ratio at 40%, followed by 'low skill' (26%), 'overtension' (13%), and 'lack of practice' (13%).

In terms of injury patterns, 'ear' accounted for the highest percentage of the entire 'head and face' injuries at 58% among ocean divers, while 'ankle' (37%), 'shoulder' (31%), 'finger' (31%) and 'knee' (31%) are the most frequent injured parts among sports divers in the respective body areas of 'head and face', 'upper extremity,' and 'lower extremity'. The most frequent injured body parts among dive leaders are 'knee' and 'calf'. although the aural symptoms of sports divers and dive leaders were not represented in our results, these symptoms have appeared slowly. Spira (1999) reported that if diving is the cause of aural symptoms, the nature of the aural injury needed to be clarified. And he said that barotrauma was the most likely cause; however, inner ear decompression sickness may also present with hearing loss, tinnitus, vertigo, and nausea. Clinically, symptoms of hearing loss and tinnitus due to either barotrauma or decompression sickness may be ambigu-

ous (Newton, 2001; Spira, 1999). As mentioned, evidence indicates that central nervous system degeneration (secondary to subclinical decompression sickness) is demonstrable among experienced divers (McQueen et al., 1994; Reul et al., 1995; Walker and Edmonds, 2002). Hence, it is conceivable that such subclinical decompression sickness of central nervous system might also be a cause of the aural symptoms reported.

With respect to the person who performed aid-first, 'instructor' accounted for the highest percentage at 41% among ocean divers, followed by 'self' (25%); among sports divers, 'instructor' and 'self' equally took up 31%; in terms of dive leaders, 'Self' accounted for the highest percentage at 46%. As scuba diving is a physical activity that requires a diver to breathe through a self-contained underwater breathing apparatus under water, the sports is suitable for people without cardiovascular and circulatory diseases and is strictly prohibited to people who have the medical history of lung, heart, brain, and endocrine system diseases, as well as asthma and seizure (Bove, 1996; Kim and Choi, 2010; Shin and Park, 2005). Other risks that are likely to happen during scuba diving include increased heart rates and hyperventilation caused by overtension and overaction, as divers are exposed to various elements such as water temperature, water pressure, tidal waves, and poor visibility in the underwater environment (Kim and Choi, 2010).

As the study results show that 'overtension' and 'low skill' are the main injury causes among beginners and intermediates, regular practices and efforts to improve skills are needed to prevent scuba diving-related injuries (Morgan, 1995). And it is also important to pay more attention to the development of an effective rescue procedure so that first-aid is provided immediately after an injury occurs. And with the regard to first aid performers, more efforts need to be made to improve divers' low dependence on specialists for treatment and consultation so that we can prevent an injury from leading to the second injury accident.

This study has several limitations. First, we surveyed only BSAC diving club members. Second, because participation in the study was voluntary, it is possible that the sample was skewed toward divers who had sustained a diving injury; thus, some injury rates may be overestimated. Third, even though our sample size was so small, it represents only a small proportion of active recreational divers in Korea. Unfortunately, we could not obtain a response rate in this study because very few club representatives reported the number of members.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENTS

This study was supported by the Research Grant of Chungnam National University in 2015.

REFERENCES

Bove AA. Medical aspects of sport diving. Med Sci Sports Exerc 1996;28:591-595.

Elliott D. Why fitness? Who benefits from diver medical examinations? SPUMS J 2000;30:206-209.

Kim BY, Choi JI. The changes of heart rate, body temperature and oxygen saturation according to water area in scuba diving. Korean J Sport 2010;8:371-379.

McQueen D, Kent G, Murrison A. Self-reported long-term effects of diving and decompression illness in recreational scuba divers. Br J Sports Med 1994;28:101-104.

Morgan WP. Anxiety and panic in recreational scuba divers. Sports Med 1995;20:398-421.

Newton HB. Neurologic complications of scuba diving. Am Fam Physician 2001;63:2211-2218.

Reul J, Weis J, Jung A, Willmes K, Thron A. Central nervous system lesions and cervical disc herniations in amateur divers. Lancet 1995;345:1403-1405.

Richardson D, Kinsella J, Shreeves K. The encyclopedia of recreational diving. 3rd ed. Rancho Santa Margarita (CA): PADI; 2008.

Shin SH, Park IR. The effects of diving career on physiological responses of scuba diver. Korea Sport Research 2005;16:377-386.

Spira A. Diving and marine medicine review part II: diving diseases. J Travel Med 1999;6:180-198.

Walker R, Edmonds C. Long-term effects of diving. In: Edmonds C, Lowry C, Pennefather J, Walker R, editors. Diving and subaquatic medicine. 4th ed. London: Arnold Publishers; 2002. p. 457-464.

 http://dx.doi.org/10.12965/jer.150252