

SKYDIVING AND THE RISK OF CERVICAL DISC HERNIATION

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Abstract

The skydiving/parachuting sport which has recently gained popularity is also known for its accidents and injuries. However, there are a few studies related to its occupational ergonomic risks and occupational musculoskeletal diseases. It has been reported that the sudden hyperextension of the neck during the parachute opening, so called opening shock results in neck pain. It has been found that the jumpers are subjected to an average deceleration of 3–5 times the earth's gravitational acceleration (3–5 G) during parachute opening shock. It is considered that the spinal cord is destabilized by the impact of this force. This study presents the occupational cervical disc herniation occurring in the case of a subject who has been working as a skydiving/parachuting instructor for 25 years, and the ergonomic risks specific to the sports of skydiving. There is a requirement for systematic and representative studies related to the administrative measures to be taken in order to prevent the occupational diseases that may occur in the case of skydivers, the personal protective equipment to be used, and the employee. *Int J Occup Med Environ Health* 2018;31(2):243–249

Key words:

Ergonomics, Parachuting, Skydiving, Disc hernia, Opening shock, Work-related disorders

INTRODUCTION

Musculoskeletal diseases are amongst the most frequent diseases which result in early retirement, sick leave as well as financial loss. It has been reported that even people with no complaints have 50% disc degeneration, loss of height and bulging when explored by computed tomography (CT) imaging [1]. Associations between individual characteristics like age, sex, muscle strength and endurance, physical fitness, body size, personality, intelligence, leisure time habits (physical activity, smoking, alcohol,

diet) and musculoskeletal diseases are known and well defined [2].

Musculoskeletal diseases, which are quite frequent in the normal population, are seen 3 to 29 times more often after having been subjected to workplace exposures [3]. These disease may be categorized as occupational diseases that describe any disease contracted as a result of exposure to dangerous substances or conditions arising from work activity, or more often are categorized as work-related diseases that have multiple causes, in the case of which factors

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in the work environment may play a role, together with other risk factors, in the development of such diseases.

Occupational diseases and work-related diseases arise at earlier ages and have different epidemiologic specifications when compared to normal population. The epidemiologic parameters used for diagnosing these diseases are obtained by taking a detailed working history which defines the ergonomic and psychosocial risk factors, the cause-effect relationship and temporal or time sequence between these risk factors and the musculoskeletal disease occurrence, and seeing if more than one employee performing the same task has similar complaints [4].

It has been defined that certain ergonomic and psychosocial risk factors at the working environment, such as monotonous tasks, repetitive movements, heavy lifting and perceived psychological stress, poor control of work organization cause occupational or work-related musculoskeletal diseases (WRMSD). One of the most common WRMSD is cervical disc herniation, and the major risk factors for its development have been defined as working in a position that bends the neck forward, heavy lifting and static posture [5,6]. Prolonged flexion, extension, lateral bending and twisting of the neck increase muscle fatigue, and may lead to chronic muscle injuries and degenerative changes of the cervical spine [2]. Many risky occupations and workers such as construction industry workers, health care workers, aviators, miners have already been known and well defined [7–10].

Although hyperextension is one of the well-known risk factors for cervical disc herniation in accidents like a car crash, it is not well documented as one of the exposures for occupational settings. During a sudden and forceful extension movement, the front and back extensor muscles, the shoulder muscles and flexor muscles of the neck are exposed to an excessive load which destabilizes the spinal cord and may result in cervical disc herniation. The risk of hyperextension has been defined as a major risk factor

for skydiving, which involves movements such as jumping from a high altitude and a sudden deceleration after parachute opening [11]. Skydiving, which is mainly known for military parachuting and work-related accidents, also constitutes a high risk group for WRMSD, but the literature regarding occupational or work-related diseases is limited [12,13].

This study presents the WRMSD occurring in the case of a skydiving/parachuting instructor and aerial cameraman. With this case report, we aim to draw attention to the ergonomic risks and WRMSD resulting from skydiving, which is not only an uncommon and unusual occupation but also a common sport done for recreational purposes.

CASE

A forty-seven-year-old male applied to our occupational disease out-patient clinic due to neck pain, numbness at both arms, and tinnitus at both ears. He stated that he had had neck pain which had spread to both his arms for the last 12 years. He had been receiving physiotherapy at another health care center and taking nonsteroidal anti-inflammatory drugs (NSAID) for the last 2 years, but had not benefited from these therapies.

He stated that he had had tinnitus at both his ears for the last 15 years but he had not previously applied to any health care provider regarding this complaint.

The case's general condition was well. The physical examination revealed that his posture and gate was normal, but the neck joint's range of motion was extremely limited at every direction and was painful. The respiratory system, cardiac system and auditory examinations were evaluated as normal.

Occupational history

He has been working as a skydiving/parachuting instructor and air cameraman since 1990 and makes an average of 100–300 skydives annually. He jumps approximately from 4000 meter above ground level (mAGL),



Photo 1. The camera system used until 2009 by skydiving/parachuting instructor during jumping to record the jump

usually together with a trainee during jumping and he uses a helmet-mounted camera in order to record the jump. Until the new and smaller cameras were released 7 years ago, he had been using old version cameras which had weighed 1.5 kg (Photo 1). His terminal vertical velocity reaches up to 210–250 km/h during the period between his initial jump from the airplane till the opening of the parachute. When he deploys his parachute at approximately 1000 mAGL, he is suddenly suspended in the air, and his neck is thrown backwards accompanied with neck pain. His whole body suffers from the strain of the landing. Fourteen skydivers work in the same workplace and many of them also have musculoskeletal symptoms.

Workplace health records have revealed that the health examination prior to his employment was normal. According to the periodical workplace examinations between 2002 and 2015 his neck pain and tinnitus were recorded. However, no radiologic evaluation was performed. He regularly uses a standard personal protective equipment relevant for skydiving such as a helmet, goggles, earplugs, knee pads and a jumping suit. He did not register any additional work. He grows flowers in his own garden as a hobby. He has smoked 6–7 cigarettes per day for 15 years.

Personal medical history

He graduated from a university. He had many work-related accidents in 1999, 2011, 2013, and 2015 in relation to parachute landing. His metatarsal bones were broken and his soft tissue was injured due to heavy landing. He had a nasal sinus operation in 2011. He has no regular medications and chronic illnesses. He said that his mother had diabetes mellitus and asthma. He has 7 siblings, all in good health.

Due to the occupational risk factors described by the case and his physical examination findings, the case was referred to the ear nose throat (ENT), and the physical therapy and rehabilitation (PTR) outpatient clinics, and he was evaluated there by the specialist physicians. Ear, nose, throat and PTR consultations concluded that the findings were in accordance with bilateral normal hearing and cervical magnetic resonance imaging (MRI) and electromyography (EMG) was recommended due to the existing physical examination findings, respectively.

According to cervical MRI examination there are central posterior and diffuse chronic disc herniations accompanied by chronic degenerative changes at the C3/4, C4/5, C5/6 and C6/7 vertebral levels. The neural foramina especially at the C5/6 and C6/7 vertebral levels have been narrowed due to bilateral chronic changes (Photo 2). Electromyography was considered as normal. According to the job history and findings of physical examination, and the MRI imaging findings, the case concluded as cervical disc herniations at multiple levels, and he was advised to carry out physical therapy. He was advised to avoid exposure to neck extension during the jumps.

The occupational health council interpreted the cervical disc herniations at multiple levels, due to the exposure to opening shock and repetitive neck hyperextension during free fall – as a work-related musculoskeletal disease (Photo 3).

A written informed consent has been obtained from the patient and council in order to prepare this case report.



Arrows – C5/6 and C6/7 vertebrae.

Photo 2. The skydiving/parachuting instructor neck magnetic resonance imaging narrowing of the neural foramens (especially at the C5/6 and C6/7 vertebral levels) due to bilateral chronic changes



Photo 3. The position of the skydiving/parachuting instructor (the person with a helmet-mounted camera) during a skydive

DISCUSSION

This case is significant as it draws attention to the WRMSD resulting from long term exposure to ergonomic risk factors in the sportive/civilian skydiving sports field which is mostly known for its accidents and injuries. There are very few studies regarding the WRMSD occurring in this field. The sport of skydiving has recently gained popularity. According to the available data from the United States Parachute Association (USPA), 3.5 million skydives were made in the United States (USA) during the year 2000. The USPA also reports that 317 741 people made at least one skydive in the USA and 34 217 new licenses were issued in 2000 [14]. According to the International Parachuting Commission (IPC) of the World Air Sports Federation, 4.7 million skydives were performed in 40 countries in 2009 [13]. The health-related literature regarding this field mainly focuses on accidents and injuries.

The scientific research regarding injuries and accident risks in skydiving has been carried out mainly on military skydiving. Dawson et al. have reviewed the data obtained from a parachute sports club in the United Kingdom, and have reported that the average number of injuries was 28/year (range 23–36) [15]. Knapik et al. have reported 242 injuries out of 23 031 jumps [16].

Aside from the accidents, occupational diseases or work-related diseases are also among the main problems of skydiving. Several factors contribute to musculoskeletal diseases. During a skydive, the skydiver descends from a very high altitude to the ground level in a very short period. The human body is traumatized due to the forces and pressure differences during this period. Minor strains, impacts and micro traumas which do not result in immediate injuries are summed up and cause chronic conditions. Among these exposures, the most important one is the parachute opening shock (POS) [12].

According to the formula for converting potential energy into kinetic energy, when an approximately-80-kg person skydives at around 4000 mAGL, a terminal vertical veloc-

ity of approximately 200 km/h is reached in 10–15 s [17]. The parachute is deployed at approximately 1000 mAGL, slowing a skydiver from the terminal vertical velocity to approximately 20 km/h in a few seconds, causing a sudden deceleration called as the POS. Prior investigations have found that a skydiver is subjected to average decelerations of 3–5 times the earth's gravitational acceleration (3–5 G) during the POS. During the POS, the parachute canopy suspends a skydiver from the shoulders. Since a skydiver's body is parallel to the ground during the free fall, a skydiver is exposed to a force which bends all his/her vertebra and neck towards his/her back (hyperextension).

As a result of this event, the stability of the muscles and the spinal cord is lost, especially at the neck region [11]. It has been reported that this movement created by the POS which throws/flings the head back may result in trauma and injuries at the thoracic, lumbar, and especially the cervical vertebra. Nilsson et al. have reported that among the 658 skydivers they had surveyed, 25% of them had reported that they had had neck pain during or after the parachute had been opening [13]. Neck pain prevalence was reported by 30% of men, 60% of women aged 16 to 65 years old in Gothenburg [2] and Fejer et al. have reported 48.5% prevalence [18] in general population. It may be expected that skydivers are more healthy and fit in comparison to general population.

Moreover, those who have musculoskeletal disorders cannot continue to work as skydivers (healthy worker effect). Bar-Dayyan et al. have reported that out of the 74 parachuting instructors they had studied, 10.9% of them had had moderate, and 5.5% of them had had severe degenerative disease of the lumbar spine. However, during this study they did not reach a diagnose but only evaluated the complaints or the radiographic findings [12]. Our case had cervical disk herniations at multiple levels, and his lumbar MRI was normal except for chronic degenerative changes.

It has been indicated that the helmets and helmet-mounted cameras the sportsmen or instructors wear may also be

a major risk factor. The reports based on the complaints have pointed out that the sportsmen who wear helmets and helmet-mounted cameras experience more neck pain [13].

Occupational or work-related diseases are diseases which may be prevented by controlling the risk factors. The ergonomic interventions in order to prevent the occupational diseases (OD), and particularly the WRMSD that may occur in the case of skydivers should also be utilized. In order to decrease the hyperextension occurring during the skydive, it should be considered to modify the process by developing various jumping styles, parachute models or supporters. It may be a good alternative to use a safety belt with a shock absorber similar to the ones used at high altitude jobs, in order to decrease the force which a skydiver is being exposed to. Until these are provided, it is important that the parachute and other equipment are made from good quality and appropriate material, and that their maintenance and repair are done attentively.

The latest technological developments in this area should be followed and their usage should be ensured. The fact that our case has begun to use smaller helmet-mounted cameras during his skydives is a good example. The administrative preventive measures that could be taken for occupational skydiving may be listed as decreasing the working hours and providing enough rest time, and entitlements for changing the workplace or early retirement. The employees should be taught the proper jumping and landing positions which minimize the injuries, and it should be ensured that they follow the recommendations. It is known that proper landing techniques decrease traumas [19]. The trainings should be repeated and updated following a work-related accident, re-employment, or the usage of relevant equipment. Close follow-up and survey of an employee's complaints provides an opportunity to catch and diagnose the health problems at their onset. The subjects should be taught stretching exercises for strengthening and lengthening the muscles especially at the neck

region, and it should be ensured that they perform these exercises.

In addition to these, it is quite important to ensure that proper personal protective equipment is used, instructions for usage are given, and that their maintenance is done. It has been reported that the usage of ankle braces reduce the traumas such as ankle sprain and ankle injuries which occur during landing [20]. The usage of personal protective equipment for the neck region should be considered in order to reduce the neck traumas. Not only the studies regarding accidents but also the ones aiming to prevent occupational diseases should be given importance. New developments are required in order to decrease the ergonomic risks.

The case we have presented is significant in terms of drawing attention to the ergonomic risks specific to the field of sportive and recreational skydiving. Representative studies are required in order to evaluate the extent of the health problems and possible measures that may be taken for preventing work-related accidents and occupational diseases that may occur among skydivers.

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