J Int Acad Phys Ther Res 2018; 9(4): 1657~1662
ISSN 2092-8475

www.iaptr.org
https://doi.org/10.20540/JIAPTR.2018.9.4.1657

Injuries in Female Elite Athletes in Rowing: A 1-year Prospective Epidemiological Study

This epidemiological study aims to determine the incidence, areas, severity, and time of occurrence of sports injuries in elite female rowing athletes who were training at the Jincheon National Training Center for a 1-year period from January 1st to December 31st, 2017. According to the daily injury reports form of the IOC, sport events, weight division, injured area, and cause of injury were recorded, and the following results were found. Upon comparing the incidence of sports injuries, there was a significant difference in weight of double scull athletes. In terms of sports, there was a significant difference between pair and athletes who played double skull. Injuries occurred most commonly in the lower extremity (40.5%), followed by the trunk (35.1%), upper extremity (24.3%). for all athletes in rowing. The knee and lumbar spine/lower back were the most common injury sites. More than 60% of all injuries were Level III, and injuries occurred most frequently during training, followed by weight training and then competition.

Key words: *Rowing injury; Sports injury; Incidence of sports injury; Parts of sports injury*

Ki Jun Park, Ph.D[a], Hyun Chul Kim, Ph.D. Yang, Rae Kim, Ph.D[b]

[a]Department of Medicine & Science, Korean Sport Olympic and Committee, Jincheon ; [b]Department of physical therapy center of samsungbon hospital, Hwaseong Republic of Korea

Received : 01 October 2018
Revised : 09 November 2018
Accepted : 16 November 2018

Address for correspondence
Hyun Chul Kim, PT, Ph.D
Department of Medicine & Science, Korean Sport Olympic and Committee, 105, Seonsuchon-ro, Gwanghyewon-myeon, Jincheon-gun, Chungcheongbuk-do 27809, South Korea
Tel: 82-10-5637-9820
E-mail: kzang78@sports.or.kr

INTRODUCTION

Races involving paddling in a boat began several hundred years ago and have historical tradition. FISA was established in 1892, which makes it the oldest sports association in the history of Olympics [1]. Prior to the Montreal Olympics in 1976, only male athletes participated in the Olympics, but as female athletes began participating with the emergence of Title IX, which banned sex discrimination, the number of athletes in rowing races has consistently increased. Seiler (2004) suggested that the increase in the number of participants encourages important health benefits, such as decrease in cardiovascular diseases, diabetes, and obesity that rowing provides [2]. Rowing in Korea has continuously improved since winning the gold medal at the 2006 Asian Games in Doha, and as a result, Korea hosted the 2013 World Rowing Championships, which provided an opportunity for Korea to take the next step forward as a member of the international arena. The rowing athletes of Korea have been participating in intense training and various competitions to enhance performance in international competitions. Meanwhile, McGuine (2006) suggested that special technical skills and basal physical fitness are required for all sports athletes, and that repetitive participation in competitions and intense training are essential factors to put out the best performance. As such, because rowing athletes participate in repetitive intense training and various competitions, sports injuries in various body parts occur frequently [3]. Valk and Pivalica (2004) suggested that sports injuries are considered a very important variable related to the athletes' competition and training [4].

In addition, Rumball et al. (2005) suggested that because rowing is a highly technical sport, it is easy to become injured when using wrong techniques [5]. Recently, the International Olympic Committee (IOC) has been conducting various studies to prevent sports injuries in athletes, reporting important epidemiological

data through standardized evaluation of sports injuries, and putting in much effort to identify the risk factors and their causes related to sports injuries [6]. With increased importance of sports injuries, studies related to sports injuries among rowing athletes have been conducted [3, 7, 8] but there has not been any extensive epidemiological investigation conducted. There also has not been any study on sports injuries from rowing in Korea. In fact, there was an epidemiological study that investigated sports injuries that developed among the members of the Korean national team from the 2002 Asian Games held in Busan and 2010 Asian Games held in Guangzhou [9, 10]. However, an extensive epidemiological survey of a single sport was not conducted because it investigated sports injuries of various sports during specific meets. Therefore, this epidemiological study aims to determine the incidence, areas, severity, and time of occurrence of sports injuries in elite female rowing athletes who were training at the Jincheon National Training Center for a 1-year period from January 1st to December 31st, 2017.

SUBJECTS AND METHODS

Subjects

This epidemiological study included 8 female rowing athletes of the national team who stayed and trained at the Jincheon National Training Center for a 1-year period from January 1st to December 31st, 2017. By events, 2 single scull athletes (1 lightweight, 1 heavyweight), 4 athletes who played double scull (2 lightweights, 2 heavyweights) and 2 pair athletes (2 heavyweights) were included.

Study method and data collection

Among the rowing athletes who stayed and trained at the Jincheon National Training Center for 1 year from January 1st December 31st, 2017, all acute and chronic musculoskeletal symptoms and signs related to sports activities that occurred from participating in competitions and internal and external training were defined as sports injuries and recorded [11]. During the study, the athletes were assessed by one of two sports medicine doctors who completed the daily injury report forms on site before referring the athletes to the training centre clinic. For all records of the athletes, sport and events, weight division, injured area, and cause of injury were recorded based on the daily injury report form of the IOC [12]. If one athlete had multiple sports injuries in various areas, then each injury was classified as a separate sports injury. Depending on the severity, sports injuries were classified as Level I for 1-3 days of treatment (mild injury), Level II for 4-7 days of treatment (moderate injury), and Level III for 8 or more days of treatment (severe injury) [13]. In addition, the time of occurrence was classified as during training, competition, or weight training. Injury areas were classified as head and neck, upper extremity, trunk, and Lower extremity in accordance with the areas used by the IOC during the Olympics [12], and the areas were segmented into neck/cervical spine, shoulder/clavicle, upper arm, elbow, forearm, wrist, hand, thumb, finger, sternum/ribs, thoracic spine/upper back, abdomen, lumbar spine/lower back, pelvic/sacrum/buttock, hip, thigh, knee, lower leg, calf, achilles, ankle, and foot/toe.

Data processing method

General characteristics of all sports injuries were analyzed by descriptive statistics. To determine the sports injury incidence (IR) among rowing athletes, the incidence of injury per 1000 hours and the incidence of injury according to 1,000 exposures (1000 AE) were analyzed, and the Poisson Distribution was used to obtain the Z score by assessing the statistical significance of data when the average rate of injury in a fixed interval of time was compared within different groups. In addition, the Chi-square test and RR (relative ratio) were performed to compare the injury location, injury level and injury type for each sport. The statistical significance level was $p < .05$. For data processing, SPSS ver 23 (IBM Corp, Armonk, New York, USA) was used.

RESULTS

Rowing athletes train on average 4.8 hours per day. They trained 260 days out of a year for 1,248 hours and training exposure was 480 AE. There were 37 cases of sports injuries, out of which 16 were in double scull, 12 in pair and 9 in single scull athletes.

Incidence of sports injuries

Injury incidence per 1,000 hours in rowing athletes was 3.71 cases. That of single scull athletes was 3.61 cases (lightweight 4.01 cases, heavyweight 3.21 cases $z=0.633$, $p=0.526$), double scull was 3.21 cases (light

weight 1.6 cases, heavyweight 4.81 cases z=3.581, p=0.0003) and pairs were 4.81 cases. The 1,000 AE injury incidence was 9.88 cases. That of single scull was 9.62 cases (lightweight 10.68 cases, heavyweight 8.55 cases z=1.03, p=0.301), double scull was 8.55 cases (lightweight 4.27 cases, heavyweight 12.82 cases z=5.85, p<0.000) and pairs were 12.82 cases (pair VS double scull z=2.070, p=0.038).

Table 1. Areas of sports injuries

Site	No(%)				
	Single scull		Double scull		Pairs
	Lightweight	Heavyweight	Lightweight	Heavyweight	–
Head	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Face	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Neck/Cervical spine	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Head and Neck	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Shoulder/Clavicle	1(20)	1(25)	N/A(0.0)	1(8.3)	1(8.3)
Upper arms	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Elbow	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	1(8.3)
Forearm	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Wrist	1(20)	N/A(0.0)	N/A(0.0)	1(8.3)	N/A(0.0)
Hand	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Finger	N/A(0.0)	N/A(0.0)	1(25)	N/A(0.0)	1(8.3)
Thumb	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Upper extremity	2(40)	1(25)	1(25)	2(16.7)	3(25)
Sternum/Ribs	N/A(0.0)	1(25)	N/A(0.0)	2(16.7)	N/A(0.0)
Thoracic spine/Upper back	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Abdomen	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Lumbar spine/Lower back	N/A(0.0)	1(25)	2(50)	3(25)	1(8.3)
Pelvic/Sacrum/Buttock	1(20)	1(25)	N/A(0.0)	N/A(0.0)	1(8.3)
Trunk	1(20)	3(75)	2(50)	5(41.7)	2(16.7)
Hip	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Groin	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Thigh	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Knee	1(20)	N/A(0.0)	N/A(0.0)	4(33.3)	5(41.7)
Lower leg	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Achilles tendon	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)	N/A(0.0)
Ankle	1(20)	N/A(0.0)	N/A(0.0)	N/A(0.0)	1(8.3)
Foot/Toe	N/A(0.0)	N/A(0.0)	1(25)	1(8.3)	1(8.3)
Lower extremity	2(40)	N/A(0.0)	1(25)	5(41.7)	7(58.3)
Total	5	4	4	12	12

Areas and severity of sports injuries

The sports injuries in rowing athletes were most common in the order of lower extremity (40.5%), trunk (35.1%) and upper extremity (24.3%) and there were no injuries of the head and neck. For all rowing athletes. The knee, lumbar spine/lower back were the most common injury sites. Details regarding the areas of sports injuries are as shown in (Table 1). More than 60% of all sports injuries were level III, followed by Level II (27%) and level I (10.8%). Upon comparing sports injury incidence (IR) of Level III and Level II injuries, Level III injury incidence was 2.3 times greater with RR=2.30, 95%CI= 1.28-4.13(p=0.005), while Level III injury incidence was 5.75 times greater with RR=5.75, 95% CI=2.20-15.00(p=0.001) when comparing Level III and Level I sports injury incidence (IR). There were no statistically significant differences in other comparisons. The details on the severity of sports injuries are as shown in (Table 2).

Time of occurrence of sports injuries

More than half of all sports injuries occurred during training (59.5%), followed by weight training (24.3%) and competition (16.2%). Upon comparing the sports injury incidence (IR) between training and weight training injuries, training injury incidence was 2.44 times greater with RR=2.44, 95%CI=1.30-4.58 (p=0.0047), while training injury incidence was 3.67 times greater with RR=3.67, 95%CI=1.69-7.99 (p=0.0003) when comparing training injury and competition injury incidence (IR). The details on the time of occurrence of sports injuries are as shown in (Table 3).

DISCUSSION

Prior studies on sports injuries of Korean national team's rowing athletes were focused on injuries during a specific competition period [9, 10]. Although direct comparison of the results is difficult due to the difference in study design, the results of 1,000 AE injury incidence and the high incidence during training were similar [10]. In addition, our study showed significant differences in injury incidence by events and weight division. This is believed to be due to the differences in the training method, duration of the competition, and techniques used in each sport variation [14].

Incidence of sports injuries

The area with the highest injury incidence in this study was the knee. Karlson (2000) explained that Iliotibial band syndrome can develop because of the pressure at the knee while rowing and that anatomically, female athletes are prone to knee joint problems [7]. Furthermore, the inappropriate angle and placement of the foot were pointed out as the cause of knee injuries. The next most common injury occurred in the lumbar spine/lower back. Tritz et al. (2003) explained that lumbar spine/lower back injuries are likely to recur within a week.15 With time, rowing athletes could develop lumbar spine/lower back injuries that are generally related to the development of muscle asymmetry [16, 17]. Meanwhile, EunKuk Kim (2005) suggested that lumbar spine/lower back injuries, caused by various diseases combined, have the highest incidence among elite athletes [18]. Koutedakis et al. (1997) found the correlation between the maximum torque ratio of the knee in rowing athletes and lumbar spine/lower back

Table 2. Severity of sports injuries

Severity of injuries	No (%)				
	Competition	Weights	Training	Overall	RR (95% CI)
level I	2(33.3)	–	2(9.1)	4(10.8)	–
level II	4(66.7)	2(22.2)	4(18.2)	10(27)	level I ref. 2.30(1.28 to 4.13)
level III	–	7(77.8)	16(72.7)	23(62.2)	level I ref. 5.75(2.20 to 15.00)

Table 3. The time of occurrence of sports injuries

Time of occurrence	No (%)	RR (95% CI)
Competition	6(16.2)	–
Weight training	9(24.3)	Competition ref. 2.44(1.30 to 4.58)
Training	22(59.5)	Competition ref. 3.67(1.69 to 7.99)

injuries. They reported that after 6-8 months of participating in a hamstring strengthening program, lumbar spine/lower back injuries decreased in female rowing athletes [19]. Shoulder injuries also accounted for more than 10% of the injuries. According to previous studies, athletes can often develop pain in the glenohumeral head due to the combination of a tight posterior shoulder capsule, tight latissimus dorsi and weakened rotator cuff muscles [20].

Areas and severity of sports injuries

In this study, it was identified that sports injuries occurred mostly in the lower extremities, followed by the trunk, upper extremities, and head and neck. However, overseas studies reported that trunk injuries were most common, followed by lower extremity, upper extremity, and head and neck [21, 22]. This may be due to the differences in techniques used, and physical ratio and strength [23]. Further, defining the severity of sports injuries is difficult [24]. Currently, most studies use the definition of sports injuries as time lost but can vary from the partial time lost from competition or training to all time lost from competition or training [11]. Such use of a simple definition of time lost can cause serious error. First, an injury that occurred on a Friday night can be resolved by resting over the weekend and adjusting practice time on the following Monday [24]. Second, an athlete can choose to not participate in practice based on one's subjective decision on the severity of the injury [24]. A previous study noted that most wrestling injuries were not serious; however, no specific definitions for severe and very severe categories were provided [5]. In our study, the time of occurrence of sports injury significantly influenced injury severity. However, our findings could not be compared with previous observations, as other studies lacked information concerning injury severity and time of occurrence of sports injury.

Time of occurrence of sports injuries

In the present study, the time of occurrence of sports injury was investigated, which was not conducted in previous studies. Most sports injuries occurred during training (about 60%). This may be because longer time is spent during training than competition and weight training. In addition, there was a significant difference between the time of occurrence and severity of sports injuries. Most severe injuries (Level III) occurred during training. Wolman et al. (1990) stated that rowing athletes can develop various severe musculoskeletal injuries due to the nature of particular and repetitive training. Moreover, because rowing requires high technical skills, severe injuries can be caused by repeating wrong techniques [25]. However, fatal or permanent injuries are very rare [8] and such severe sports injuries can be controlled by appropriate coaching [26]. McNally et al. (2005) also suggested that heavy load caused by a strong catch can be reduced by a light catch and fast and steady acceleration [8].

CONCLUSION

The present study included female rowing athletes of the national team throughout 1 year of the official training season but research on the recurrence of the injuries was not conducted at the same time. However, the risk of sports injuries and the types of sports were assessed together to conduct a valid study on the occurrence of sports injuries. In addition, because the frequency and characteristics of sports injuries vary with each event of rowing sport and weight division, this study could be helpful to prevent sports injuries by determining the areas where sports injuries often occur for each event. Upon comparing the incidence of sports injuries, there was a significant difference of weight in double scull athletes. In terms of sport variation, there was a significant difference between pair and double scull athletes. The most common area of sports injuries was lower extremity (40.5), followed by trunk (35.1%) and upper extremity (24.3%), of which knee and lumbar spine/lower back injuries were most common. More than 60% of all injuries were Level III, and the time of occurrence of sports injuries was in the order of injuries during training, weight training and competition.

REFERENCES

1. World Rowing Federation http://www.worldrowing.com/
2. Seiler S. Masters rowers who were they, who are they, and why do they love it so much? Presented at the International Rowing Federation Joint Meeting of Developmental Committees; London, United Kingdom. 2004.
3. McGuine TA. Sports Injuries in High School Athletes: A Review of Injury Risk and Injury

Prevention Research. Clin J Sports Med. 2006; 16(6): 488-499.
4. Valk T, Pivalica D. Handball: The Beauty or the Beast. Croat Med J. 2004; 45(5): 526-530.
5. Rumball JS, Lebrun CM, DiCiacca S, et al. Rowing Injuries. Sports Med 2005; 35(6): 537-55.
6. Junge A, Engebretsen L, Mountjoy ML, et al. Sports injuries during the Summer Olympic Games 2008. Am J Sports Med. 2009; 37(11): 2165-2172.
7. Karlson KA. Rowing injuries. Phys Sports med. 2000; 28(4): 40-50.
8. McNally E, Wilson D, Seiler S. Rowing injuries. Seminars in Musculoskeletal Radiology. 2005; 9: 379-396.
9. Yang Yj, Lee JH, Lee MJ, et al. Injuries and Illnesses of Korean Athletes during 2002 Busan Asian Games. The Korean Journal of Sports Medicine. 2004; 22(2): 135-143.
10. Kim EK, Kang HY, Kim TG, et al. Sports Injury Surveillance during Summer Asian Games 2010 in Guangzhou. The Korean Journal of Sports Medicine. 2011; 29(1): 49-57.
11. Goldberg AS, Moroz L, Smith A, et al. Injury surveillance in young athletes: a clinician's guide to sports injury literature. Sports Med. 2007; 37(3): 265-278.
12. Engebretsen L, Soligard T, Steffen K, et al. Sports injuries and illnesses during the London Summer Olympic Games 2012. Br J Sports Med. 2013; 47(7): 407-414.
13. Park KJ, Brian BS. Injuries in elite Korean fencers: an epidemiological study. Br J Sports Med. 2017; 51: 220-225.
14. Knowles SB, Marshall SW, Guskiewicz KM. Issues in estimating risks and rates in sports injury research. J Athl Train. 2006; 41(2): 207-215.
15. Teitz CC, O"Kane J, Lind BK. Back pain in former intercollegiate rowers: a longterm follow-up study. Am J Sports Med. 2003; 31(4): 590-595.
16. Stallard MC. Backache in Oarsmen. Br J Sports Med. 1980; 14(23): 105-113.
17. Secher NH. Physiological and biomechanical aspects of rowing: implications for training. Sports Med. 1993; 15(1): 24-42.
18. Kim EK. Injury Management of the National Team Athletes. Journal of the Korean Medical Association. 2005; 45(10): 977-984.
19. Koutedakis Y, Frischknecht R, Murthy M. Knee flexion to extension peak torque ratios and low back injuries in highly active individuals. Int J Sports Med. 1997; 18(4): 290-295.
20. Richardson CA, Jull GA. Muscle control: What exercises would you prescribe? Manual Therapy. 1995; 1(1): 2-10.
21. Coburn P, Wajswelner H. A survey of 54 consecutive rowing injuries. In: Conference Proceedings, National Annual Scientific Conference in Sport Medicine Australian Sports Medicine Federation, Melbourne. 1993; p-85.
22. Wajswelner H, Mosler A, Coburn P. Musculoskeletal injuries in domestic and international rowing. In Conference Proceedings, Australian Conference of Science and Medicine in Sport, Hobart, Australia. 1995; p-382.
23. Sterkowicz S, Sacripanti A, Sterkowicz-Przybycieńń K. Techniques frequently used during London Olympic judo tournaments: a biomechanical approach. Archives of Budo. 2013; 9: 51-58.
24. DeLee JC, Farney WC. Incidence of injury in Texas high school football. Am J Sports Med. 1992; 20(5): 575-580.
25. Wolman RL, Clark P, McNally E, et al. Menstrual state and exercise as determinants of spinal trabecular bone density in female athletes. Br J Sports Med. 1990; 301(6751): 516-518.
26. Vinther A, Kanstrup IL, Christiansen E, et al. Exercise-induced rib stress fractures: potential risk factors related to thoracic muscle co-contraction and movement pattern. Scand J Med Sci Sports. 2006; 16(3): 188-196.