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Injuries Related to Kitesurfing

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***Abstract*—**Participation in sporting activities can lead to injury. Sport injuries have been widely studied in many sports including the more extreme categories of aquatic board sports. Kitesurfing is a relatively new water surface action sport, and has not yet been widely studied in terms of injuries and stress on the body. The aim of this study was to get information about which injuries that are most common among kitesurfing participants, where they occur, and their causes. Injuries were studied using an international open web questionnaire (n=206).

The results showed that many respondents reported injuries, in total 251 injuries to knee (24%), ankle (17%), trunk (16%) and shoulders (10%), often sustained while doing jumps and tricks (40%). Among the reported injuries were joint injuries (n=101), muscle/tendon damages (n=47), wounds and cuts (n=36) and bone fractures (n=28). Also environmental factors and equipment can influence the risk of injury, or the extent of injury in a hazardous situation. Conclusively, the information from this retrospective study supports earlier studies in terms of prevalence and site of injuries. Suggestively, this information should be used for to build a foundation of knowledge about the sport for development of applications for physical training and product development.

***Keywords*—**Kitesurfing, injuries, injury cause, questionnaire.

I. Introduction

SPORTING injuries are a result of excessive loading, during a short or long time, that causes tissue failure. Musculoskeletal stress and injuries due to excessive loading have been studied for many sports and in many workplace situations [1-3]. However, stress and injuries resulting from some of the newer sports have not yet been sufficiently studied.

Action sports such as kitesurfing are becoming increasingly popular. In 2006 there were about 210 000 kite surfers worldwide, and it was estimated that the number would increase by 35-50% by 2008 [4]. The kitesurfer is attached by lines and a harness to a kite, and uses the wind to go forward. The force created by the wind pulls the rider along the surface of the water on a kiteboard similar to a small surfboard.

The kitesurfing injuries reported in the literature deal mainly with traumas or accidents [5-8]. These are often the result of problems with the safety systems, such as the inability to release oneself from the kite [9, 10]. A prospective study showed that the most common sites of injuries in kitesurfing are the foot and ankle complex, followed by the head, knees and thorax [6]. The injury rate has been estimated to be 7.0 injuries per 1000 hours during practising, whereas during competitions, the estimate was more than twice this: 16.6 injuries per 1000 hours of competition [6]. The physiological demands and characteristics of kitesurfing have been described in a recent study by Vercruyssen et al. (2009). They came to the conclusion that crossing (transportation over the surface of the water) requires work of moderate intensity, i.e. 81% of maximum oxygen consumption (VO_{2max}), involving a mainly static body position, similar to that in Laser sailing and windsurfing. They also found that those with a higher value of VO_{2max} showed a better performance in crossing, and hence suggested that increased physical training could enhance the performance of kitesurfers [11].

To complement the material currently available in the literature, a more recent study of injuries related to kitesurfing is needed. The overall purpose of this study was thus to obtain an overview of kitesurfing with respect to injuries and their causes. The specific goals were: (i) to identify the most common injuries among kitesurfers, (ii) to identify the parts of the body most often exposed to injuries, (iii) to elucidate which elements of kitesurfing that cause injuries.

II. Methods

A. Data Collection

Data was collected using a web-based questionnaire. All subjects participating in the study were competent at an intermediate level of kitesurfing, or better. Intermediate level was defined as being able to travel upwind and perform controlled jumps with the kite. Their kitesurfing experience varied from one to ten years, and both competitive and recreational kitesurfers participated. Subjects from all over the world completed the web-based questionnaire.

The questionnaire was distributed as an open web questionnaire in English in order to reach kitesurfers worldwide. It was constructed using Quicksearch Dialog Manager™ and developed from guidelines for the design of web questionnaires [12, 13]. The questionnaire was available for three months (11 July to 11 September 2008), via www.hh.se/kiteproject. This site was linked from kitesurfing forums, such as kiteforum.com, kitesurferen.dk, aksa.com.au and fksa.org.

The questionnaire took about ten minutes to complete, and contained questions about; (i) general information, (ii) physical activity, (iii) muscular stress, (iv) discomfort and pain, and (v) injuries, chosen from a list of musculoskeletal injuries and classified in terms of severity (mild, moderate,

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severe, catastrophic). Injury scales were adopted from earlier studies [14, 15].

The information about muscular stress, discomfort and pain was used for a parallel study of experienced musculoskeletal stress while kitesurfing [16]. A total of 347 had started the web questionnaire and it was completed by 206 international kitesurfers. Of the 206 respondents, 17 were female, 188 male and the sex of one person is not known. Their ages ranged from 16 to 62 years with a mean of 30.8, s=8.6 years, and the period they had practised the sport ranged from 1-10 years, with a mean of 4.1 years, s=2.5 years).

B. Statistical Analysis

For statistical analysis of the questionnaire data, frequencies were analysed and presented as number of respondents. The Mann-Whitney U-test and Kruskal-Wallis test of median comparison was used for statistical testing of non-parametric variables, with $p<0,05$ regarded as significant. The statistical analyses were assessed using SPSS version 17.0 (Statistical Packages for Social Sciences).

III. Results

A. Frequencies

The number of injuries reported by the 206 respondents is given in Table I. Thirty-eight percent of the respondents had sustained one or more severe injuries during the past year. In total, 251 injuries were reported on 112 injury occasions. This results in a mean of 2.2 injuries for each occasion.

Most injuries occurred while performing a jump or trick (n=102) due to poor landings or falls. In 75 of these cases the respondents also stated that environmental factors had contributed to their injury, for example, shallow water, gusty winds or choppy water. It was also reported in 76 cases that the equipment affected the extent of the injury, e.g. one foot slipped out of the strap, a cut by the fin, the kite continued to pull after falling, or the harness pressed against the thorax. Use of protective gear (helmet or impact vest) was reported as used at least sometimes by 40% of all respondents and by 40% of the group of injured respondents at the time of injury.

The results show a general injury rate of 5.9 injuries per 1000 hours of kitesurfing, based on the respondents' own estimation of the time they spend on the water. The 79 injured respondents specified the injury sites as presented in Table III. The most common site for injury was the lower extremity, counting for 45% of the specified locations. Injuries located to the trunk were rib fractures or muscle strains.

TABLE I
Reported injuries for the 206 respondents

Number of injuries	Number of respondents (n)
No injury	127
One injury	54
Two injuries	17
More than three injuries	8

There were 36 respondents reporting wound/laceration/cut as injury. Most of these were of a mild or moderate degree of severity (n=30), however five severe and one catastrophic incident of this kind were reported. Twenty-eight respondents had sustained bone fractures, 16 anterior cruciate ligament ruptures, 19 other ligament ruptures, 21 ligament strains, 15 meniscus ruptures, 16 joint dislocations and 14 other joint injuries. Ten tendon ruptures were reported, 18 muscle ruptures and 19 muscle strains. Fourteen reported internal bleeding, 10 skull injuries and 15 other injuries (Table II). Among the injuries classified as 'Other' injuries were ear problems, broken fingers, rib injuries and inflammation.

TABLE II
Self-Reported Injuries (n=251) and Contributing Factors

Type of injury	Bone fracture (n=251)	Joint injury (n=251)	Muscle/ tendon damage (n=251)	Internal bleeding (n=251)	Skull injury (n=251)	Wound/ laceration/ cut (n=251)	Other (n=251)
Number of injuries	28	101	47	14	10	36	15
Jump or trick	14	41	14	5	2	16	10
Environment	11	29	10	4	2	15	4
Tiredness	1	6	5	1	1	3	1
Other	8	17	17	4	5	12	2
Related to equipment	14	24	16	3	3	11	5

TABLE III
INJURY SITES AS REPORTED BY RESPONDENTS

Region	Injured respondents (n=79)	Percentage (%)
Head	4	4.1
Neck	1	1.0
Trunk	15	15.3
Shoulders	10	10.2
Arms	8	8.2
Hip/Thigh	4	4.1
Knee	23	23.5
Foot/Ankle	17	17.3
Other/unknown	16	16.3

Note: Some respondents have reported more than one injury site.

B. Injured versus Non-Injured Participants

Experience (years of practice) was related to the risk of being injured (Fig. 1). Those with less experience (1-3 years) had sustained relatively more injuries ($p<0.01$, $Z=-2.88$), than those in the two other groups (4-6 and 7-10 years of experience) considering the number of injured respondents. However, the group of participants with 1-3 years of experience had a lower rate of injury per hour of practising than the other two groups, i.e. 2.7 injuries per 1000 hours of kitesurfing ($p<.0.05$, Kruskal-Wallis test).

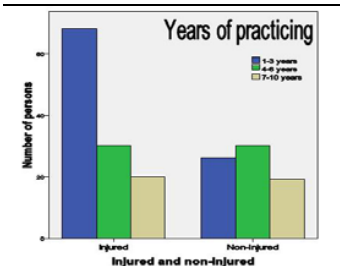

Fig. 1 Respondents with less experience (1-3 years) reported a higher number of injuries than respondents with longer experience

There was a significant difference in injuries between the respondents who were able to perform advanced tricks and those who could not (Fig. 2). Respondents who could not perform advanced tricks reported relatively more injuries during the past year ($p<0.01$, $Z=-2.92$). This result was the unchanged when compared to injuries per 1000 hours of kitesurfing.

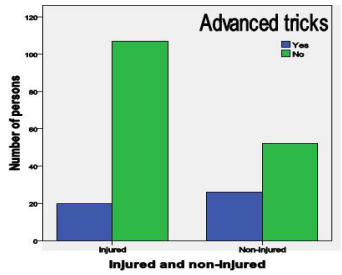

Fig. 2 The respondents who were able to perform advanced tricks were injured to a lesser extent than who could not

The prevalence of injury was significantly lower among those who claimed they warmed up "sometimes" or "often", than in those who did not, as can be seen in Fig. 3 ($p<0.01$, $Z=-4.36$).

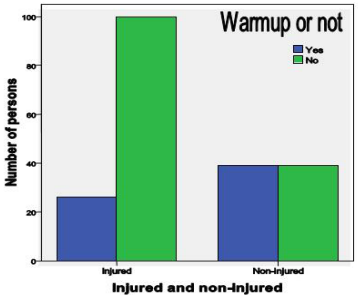

Fig. 3 Respondents who stated that they did not warm up sometimes or often had relatively more injuries than those who did

No differences were seen between the respondents who claimed they normally performed other types of physical training and those who did not, in relation to being injured or not. Neither were there any differences in injuries depending on how many hours they spent on the water each year.

IV. DISCUSSION

The aim of this study was to gain an overview of injuries that occur in kitesurfing based on the participants' own experiences. Some elements of kitesurfing place considerable mechanical stress on the musculoskeletal system. In some cases, these forces are of such an extent or applied in such a manner that severe injury occurs.

A. The Causes of Injury

Provided the wind is stable, and the wind speed is within the limit for a particular participant without causing problems for the size of kite being used, the risk of injury while crossing appears to be low. The results of this study showed that jumps and tricks were the most hazardous elements in kitesurfing. However, greater experience and warming up before a session reduced the risk of injury. Also, one should be aware of environmental factors and the inability to control some of them, and try to avoid tiredness, which increases the risk of sustaining an injury, which has also been suggested by other authors studying the sport [5-8, 10]. The fact that high speed, one foot slipping out of the strap, a gust in the middle of a jump, landing on a wave or chop, or something going wrong with the equipment can occur, shows that both uncontrollable and controllable factors are associated with the sport. The risk of injury can be reduced by preparing oneself through specific physical training, the use of safety equipment and product development.

As in many other sports where landing after jumps is important for performance, kitesurfing seems to be a sport in which injuries occur mainly in the lower extremities [17-20]. Almost half (43%) of the injuries reported in the questionnaire were located in this region of the body, many of them in

joints. Comparing kitesurfing with wakeboarding seems to be relevant since ACL ruptures and shoulder dislocations appear to be the result of unsuccessful tricks and jumps. This was especially common among athletes at higher levels according to an earlier study of wakeboarding [18]. This could not be supported by the findings from this study for kitesurfing, where higher level athletes seemed to be less injured than those who could not perform advanced tricks. A contributing factor for this could be the technical skills, since an unstable body position upon landing causes a possible risk of injury, since uncontrolled, high-speed motion is more likely to lead to unfavourable positions of the extremities and joints [21], or the more hours spent on the water for the less skilled participants.

Letting go of the bar while kitesurfing causes the kite to loose power, to which extent depends on the type of kite being used. No respondents in this study reported injuries resulting from not being able to release themselves from the kite. In 76 of the responses to the questionnaire, equipment contributed to the seriousness of the injury. It has been reported previously that not being able to release oneself fully from the kite in dangerous situations was a risk factor in kitesurfing [6]. However, all modern kites have a quick-release system so the kitesurfer can free him- or herself of the kite in the case of an emergency [9], and the new bow kites will depower as soon as the participant lets go of the bar.

B. Injury Rates

The injury prevalence of 38% derived from the responses to the questionnaire is similar to that in previous studies. Nickel et al. (2004) reported that 39% of their respondents were injured during the study period [6]. Our value should be interpreted with caution due to the limited knowledge on the exact population in this study. When comparing the injury prevalence in relation to the number of hours spent kitesurfing, the results of this study also agree with those of earlier studies. A study from the Australian kitesurfing association (AKSA) study reported 5.4 injuries per 1000 hours of kitesurfing [22], and Nickel et al. reported 7.0 injuries per 1000 hours. The respondents in this study were estimated to have had 5.9 injuries per 1000 hours. Nickel et al. found the rate to be almost doubled during competition [6], which, however, could be due to a more thorough follow-up. In retrospective studies such as the present one, it is well known that the subjects might not have been able to accurately estimate the number of hours spent kitesurfing over the period of a year, which means that calculations of the injury rate may be somewhat uncertain. However, it is not unreasonable that an intermediate level kitesurfer will have a risk of sustaining an injury around five to seven times per 1000 hours of practising. The results of this study indicated a higher prevalence of injury of the participants who were not as experienced, while the same group actually had a lower rate of injury per 1000 h of practising. The reason for this may be that those with less experience spend more time practising and hence sustain a greater number of injuries in total.

C. Methodological Considerations

The reason for choosing a retrospective approach for this study was to obtain an overview of the specific area with focus on injuries and their causes. A prospective study would have been more suitable for obtaining more detailed knowledge concerning injury rate and the nature of injuries, as has been done in the past [6, 22]. However, this retrospective study has shown the importance of gathering the participants' experiences and knowledge about the sport and its nature. The findings complement the few studies that have already been carried out within this area, and can be used to introduce new scientific perspectives to the sport of kitesurfing [5, 6, 10, 11, 23]. We are aware that the data collected in retrospective studies are subject to some uncertainty, which was another reason for collecting data with different methods in different populations.

A web-based questionnaire was chosen instead of a printed form mainly because it offers the possibility of gathering data worldwide at a reasonable cost. Also, it reduces the personal contact and influence of the researcher on the respondent. The questionnaire was designed to be easy and fast to answer, which is an important factor when gathering a comprehensive amount of reliable data [12, 13]. The target group of kitesurfers were expected to be experienced and frequent users of internet, since the nature of the sport requires both a certain financial status (for buying equipment) and the ability to check coming events and weather forecasts, etc. online.

It is impossible to estimate the effects of non-response bias, since there is no way of finding out exactly how many people saw the advertisement concerning the questionnaire and how many of these actually chose to answer it. Over half (59%) of those opening the web-based questionnaire completed it. Other web-based questionnaires used in retrospective studies have had participation rates of around 30-33% [14, 24], and the same concerns about the validity of the results have been addressed. Data collection via web-based questionnaires is a fairly new method, and has previously been used for commercial purposes. It offers great opportunities in reaching large and widespread survey groups, providing they have access to the internet [12]. According to many studies of the methodology employing web-based questionnaires lack of internet availability is one of the major biases for open web surveys [12, 24-27]. We considered a web-based questionnaire to be the most cost-effective alternative for an international retrospective study of this kind. It was successful in this study in terms of reaching the target population, but we cannot be totally sure that those answering the questionnaire truly represent the target group.

In the study group, kitesurfing competence ranged from intermediate to competitive. It is therefore likely that the participants will have different experiences of the biomechanical loads while kitesurfing, as well as different injury patterns, since the physical requirements differ depending on the level of kitesurfing. It is also difficult to know whether those who chose to complete the questionnaire differed from those who did not, for example, regarding the

number of injuries. On the other hand, those who have suffered an injury may no longer be participating in the sport and are therefore less likely to visit kitesurfing-related web sites. We believe that the mismatch in terms of gender is representative of kitesurfing participants, as the same pattern, with very few females, has been found in other studies, e.g. Nickel, et al. (2004), who had ten females out of 235 participants.

V. Conclusion

- Kitesurfing is a sport where injuries occur to an extent of 5-7 times per 1000h of practising during recreational kitesurfing, according to this and earlier studies.
- The lower extremities (knee and ankle) were the most frequent locations of injury, but rib fractures and shoulder injuries were also reported frequently.
- Jumps and tricks were associated with about 40% of the injuries reported in this study and many were also influenced by environmental factors or equipment issues.
- Physical, environmental and mental factors determine the participant's ability to perform well and avoid injury. Many of these factors cannot be controlled, but specific physical training, practising techniques and being aware of environmental conditions have positive effects on both performance and avoiding injury.
- This information can provide a foundation for further studies of kitesurfing and complements the earlier studies. A prospective study of kitesurfers of different levels of competence would be useful to obtain more detailed information on injuries and their causes, connected to specific elements of kitesurfing.

References

[1] Patel, D.R., and R.J. Baker," Musculoskeletal Injuries in Sports", *Primary Care: Clinics in Office Practice* Vol. 33, No. 2, 2006, pp. 545-579.
[2] Hincapié, C.A., E.J. Morton, and J.D. Cassidy," Musculoskeletal Injuries and Pain in Dancers: A Systematic Review", *Archives of Physical Medicine and Rehabilitation* Vol. 89, No. 9, 2008, pp. 1819-1829.e1816.
[3] Hogan, K.A., and R.H. Gross," Overuse injuries in pediatric athletes", *Orthopedic Clinics of North America* Vol. 34, No. 3, 2003, pp. 405-415.
[4] Bryja, J., "Kiteboarding statistics: Worldwide participation and sales statistics", *SBC Kiteboard*, online: SBC Kiteboard Magazine, 2008.
[5] Scheibe, E., E. Lignitz, P. Hinz, and R. Scheibe," Kitesurfen", *Rechtsmedizin* Vol. 19, No. 3, 2009, pp. 145-151.
[6] Nickel, C., O. Zernial, V. Musahl, U. Hansen, T. Zantop, and W. Petersen," A Prospective Study of Kitesurfing Injuries", *The American Journal of Sports Medicine* Vol. 32, No. 4, 2004, pp. 921-927.
[7] Ziegler, M., U. Lockemann, and K. Püschel," Tödlicher Unfall beim Kitesurfingunterricht", *Rechtsmedizin* Vol. 19, No. 3, 2009, pp. 162-164.
[8] Exadaktylos, A.K., G.M. Sclabas, I. Blake, K. Swemmer, G. McCormick, and P. Erasmus," The kick with the kite: an analysis of kite surfing related off shore rescue missions in Cape Town, South Africa", *Br J Sports Med* Vol. 39, No. 5, 2005, pp. e26; discussion e26.
[9] Petersen, W., Nickel, C., Zantop, T., Zernial, O.," Verletzungen beim Kitesurfen", *Der Orthopäde* Vol. 34, No. 5, 2005, pp. 419-425.
[10] Spanjersberg, W.R., and I.B. Schipper," Kitesurfing: when fun turns to trauma-the dangers of a new extreme sport", *The Journal of Trauma* Vol. 63, No. 3, 2007, pp. E76-80.
[11] Vercruyssen, F., N. Blin, D. L'Huillier, and J. Brisswalter," Assessment of physiological demand in kitesurfing", *European Journal of Applied Physiology* Vol. 105, No. 1, 2009, pp. 103-109.
[12] Couper, M.P.," Web surveys - A review of issues and approaches", *Public Opinion Quarterly* Vol. 64, No. 4, 2000, pp. 464-494.
[13] Couper, M.P., M.W. Traugott, and M.J. Lamias," Web survey design and administration", *Public Opinion Quarterly* Vol. 65, No. 2, 2001, pp. 230-253.
[14] Simotas, A.C., and T. Shen," Neck pain in demolition derby drivers", *Archives of Physical Medicine and Rehabilitation* Vol. 86, No. 4, 2005, pp. 693-696.
[15] Gennarelli, T.A., and E. Wodzin," AIS 2005: a contemporary injury scale", *Injury* Vol. 37, No. 12, 2006, pp. 1083-1091.
[16] Lundgren, L., S. Brorsson, M. Hilliges, and A.-L. Osvalder," Sport performance and perceived musculoskeletal stress, pain and discomfort in kitesurfing", *International Journal of Performance Analysis in Sport* Vol. 11, 2011, pp. 142-158.
[17] Kirkpatrick, D.P., R.E. Hunter, P.C. Janes, J. Mastrangelo, and R.A. Nicholas," The snowboarder's foot and ankle", *The American Journal of Sports Medicine* Vol. 26, No. 2, 1998, pp. 271-277.
[18] Carson, W.G.," Wakeboarding Injuries", *The American Journal of Sports Medicine* Vol. 32, No. 1, 2004, pp. 164-173.
[19] Torjussen, J., and R. Bahr," Injuries among competitive snowboarders at the national elite level", *Am J Sports Med* Vol. 33, No. 3, 2005, pp. 370-377.
[20] Torjussen, J., and R. Bahr," Injuries among elite snowboarders (FIS Snowboard World Cup)", *Br J Sports Med* Vol. 40, No. 3, 2006, pp. 230-234.
[21] Hagins, M., E. Pappas, I. Kremenic, K.F. Orishimo, and A. Rundle," The effect of an inclined landing surface on biomechanical variables during a jumping task", *Clin Biomech (Bristol, Avon)* Vol. 22, No. 9, 2007, pp. 1030-1036.
[22] AKSA, "Australian Kite Surfing Association: National Safety Survey 2004/5", 2005.
[23] Petersen, W., U. Hansen, O. Zernial, C. Nickel, and M. Prymka," [Mechanisms and prevention of kitesurfing injuries]", *Sportverletz Sportschaden* Vol. 16, No. 3, 2002, pp. 115-121.
[24] Fleming, C.M., and M. Bowden," Web-based surveys as an alternative to traditional mail methods", *Journal of Environmental Management* Vol. 90, No. 1, 2009, pp. 284-292.
[25] Marta-Pedroso, C., H. Freitas, and T. Domingos," Testing for the survey mode effect on contingent valuation data quality: A case study of web based versus in-person interviews", *Ecological Economics* Vol. 62, No. 3-4, 2007, pp. 388-398.
[26] Berrens, R.P., A.K. Bohara, H. Jenkins-Smith, C. Silva, and D.L. Weimer," The advent of Internet surveys for political research: A comparison of telephone and Internet samples", *Political Analysis* Vol. 11, No. 1, 2003, pp. 1-22.
[27] Jones, S., F. Murphy, M. Edwards, and J. James," Doing things differently: advantages and disadvantages of Web questionnaires", *Nurse Res* Vol. 15, No. 4, 2008, pp. 15-26.