Biomechanics of extreme sports – a kite surfing scenario

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Do extreme sports contribute to higher biomechanical stress compared to other sports?
Kite surfing is one of the upcoming popular extreme sports, where very few have studied the mechanical forces that act on the body. There are several factors that contribute to mechanical stress, and for preventing injuries it is of interest to investigate how these forces affect the body and how we can develop the equipment and prepare the athletes for making it as safe as possible.
This project will study injury prevalence, motion analysis and mapping of forces and pressure during kite surfing. The outcome will be a better understanding of biomechanics of kite surfing and a construction for testing and training.

biomechanics, kite surfing, injuries, muscle strength, motion analysis

1 Introduction

Extreme sports are becoming more and more popular, and since these sports often are associated with higher risks than other sports (Slanger, Rudestam, 1997), it is also possible that the biomechanical stress is higher and contributes to more injuries.

Kite surfing is a water sport where the practitioner goes on water with a board through the power of a kite 25 meters up in the air. The kite is attached to the body via a harness around the waist or hip (see Fig. 1) and the steering is controlled by a bar with the arms. With help from the kite you can go over the water surface in velocities up to 15-20m/s and jump high, over 20m or 65feet, in the air for doing tricks. The British Kitesurfing Organization has estimated the kite surfing population to around 100 000 practitioners world wide and it is constantly growing (BKSA, 2006).

Fig 1: The connection between harness and kite. The arrow points out the direction of pull.
Depending on the wind speed, different sizes of kites are used. Between 5m$^2$ and 16m$^2$ are the most common to use, also depending on the weight of the practitioner. Bigger kites generate more power than smaller ones. Power is achieved by moving the kite up and down through an area called “power zone” in the wind window (see Fig.2). The neutral zone is the area where the kite has minimal power and thus where you keep it while not riding.

Kite surfing is one of the upcoming popular extreme sports. The characteristics for extreme sports are high risk for the practitioner concerning endurance, danger or to push the limits and mistakes can lead to severe injuries or even death (Breivik, 2004, Slanger and Rudestam, 1997). Earlier research has shown that several factors contribute to mechanical stress on the body. Walls and Gale showed that the amount of pulling force to the harness, called the harness line force when wind surfing was around 4,9N per kg bodyweight (Walls and Gale, 2001). They measured this by connecting a load cell to the spreader bar on the harness. No similar studies are yet done in kite surfing. Therefore it is of importance for preventing injuries to investigate how these forces affect the body and how equipment can be developed for making it as safe as possible.

To this date, it is found out that it is mainly trauma injuries that are caused by kite surfing, and this often due to lack of a working quick release safety system (Petersen et al, 2005; Spanjersberg, Willem, 2004). Spanjersberg and Willem, 2004 also made the conclusion, after analyzing the sport, that the main risk factors in kite surfing are material-related, speed-related or height-related. The development of equipment is moving towards safer systems, and every year there are better possibilities released on the market. In 2006 a new type of kite was released on the market, with the purpose of having a better safety system. These kites, bow kites or Supported Leading Edge (SLE) kites, allow the rear tail of the kite to rise while sheeting out the bar, which makes the kite letting out the wind and loosing power. In addition to this, all kites have a quick release system for emergencies (United States Kitesurfing Organization, 2007).

If not only focusing on trauma injuries caused by accidents of flying on to land or obstacles while kite surfing, but on the overuse injuries caused by stress from the equipment or bad landings from tricks, the injury scenario is probably more similar to the ones in wakeboarding or snowboarding. According to earlier studies it is found that the most common sites for kite surfing injuries occurred in the foot/ankle complex, followed by the head, knee and thorax. (Nickel et al, 2004). This prospective study showed that the injury rate was 7.0 injuries per 1000h of practicing, whereas during competition it was more than double - 16.6 injuries per 1000h (Nickel et al, 2004).
Since all three previous studies that are made with kite surfers as subjects mainly have focused on trauma injuries that have been medically treated or have required acute medical care, there is a reason to look into how the musculoskeletal system is affected by the mechanical stress that is achieved from high speed, high jumps or other tricks. The surfing is for many people a hobby, but for others also a profession. As in other sports the physical demands on the athletes are high, and maybe the requirements are even higher in extreme sports like this. Are the athletes prepared enough to be able to practice kite surfing without getting injured?

2 Objectives
The project will examine how modern biomechanical technology can be used for analysis and evaluation of mechanical stresses in extreme sports. The general purpose of this project is to get further understanding of biomechanical aspects affecting the musculoskeletal system during kite surfing. Particular emphasis will be put on reducing the risk of injury while kite surfing, through enhancing the prerequisites for practitioners as well as development of equipment, to be able to reveal important aspects of muscle biomechanics.

- To get an overview of injuries and experienced influence on the musculoskeletal system from kite surfing.
- To investigate motion analysis and mechanical stresses on the musculoskeletal system while kite surfing.
- To investigate pressure on load carrying surfaces of the body while kite surfing.
- To develop a construction of a rig that can be used for testing and training extreme sports like kite surfing, wakeboarding, windsurfing etc., with the main objective of being as specific as possible.
- To evaluate specific “off-water” training for kite surfing.

3 Methods
The studies will include a mapping of the most common injuries, measuring of biomechanical factors, developing equipment for quantifying mechanical stresses and training muscular and sensorial functions for the specific movement skill (see fig. 3 and 4).

Fig 3 and 4: The whole body position for kite surfing while going on the board (fig. 3) and while jumping (fig. 4).
1.1 Study 1
The aim of this study is to map injuries and physical limitations for kite surfers. The introductory phase will consist of getting an overview from 50-100 practitioners through a survey. The subjects should be at an intermediate kite surfing level, which means that they have enough skills to handle the kite and board without any problems and know how to go upwind and do jumps with the kite. From this selection, 20 will be chosen for further interviews. The survey will ask questions about which injuries and damages, as well as getting broader information about the practitioners (sex, age, level of kite surfing, gear etc), that are the most common. Both injuries caused by trauma and overuse injuries are of interest. The study will pursue during a period of one year and interviews will be made at two times.

1.2 Study 2
The aim of this study is to obtain further knowledge concerning static and dynamic muscle forces. For studying forces, and their magnitude, that are acting on the body while kite surfing, and how the kinetics cooperates with the kinematics, there will be a use of known biomechanical measuring methods. For quantifying movement at the ankle, knee and hip joint, use of electro-goniomonitoring is probably suitable. EMG-data of the hamstrings and quadriceps will show muscle activity during the surfing and video analysis will be used to look at whole body movement. In this mapping of the biomechanics of kite surfing, also pressure between subject and load carrying surfaces, such as the back and harness, will be measured with pressure sensors. These studies will be done as a case study on one male and one female athlete while kite surfing back and forth in a regular kite surfing position (see fig. 3).

3.2 Study 3 and 4
A combination of methods developed in study I and II will be used in these two studies. With data from earlier studies as a foundation, a rig will be constructed, which can be used for analyzing biomechanical parameters during simulation of kite surfing and other extreme sports. As study group 40 subjects, 20 men and 20 age-matched women will be participating.

4 Results
The first two studies will hopefully result in an overview of how injuries and mechanical stress from kite surfing tend to affect the body and which damages it may cause. These findings will hopefully be used as a knowledge basis for enhancing the design of products used in the sport and for developing specific training methods that can prepare all athletes optimally for not being injured and perform maximally.

5 Discussion
The project is an attempt to develop the possibilities for extreme sports to become more investigated from a biomechanical perspective. Some extreme sports do already have a solid scientific background, whereas others do not. For example skiing and snowboarding, where the extreme areas are similar to the Olympic ones, have lots of studies already done. Kite surfing, wind surfing and wake boarding are not as investigated yet, and need more attention in research to become safer and for developing training principles and equipment.
On the contrary to other similar sports, such as snowboarding and skiing, there is one more force besides gravity that act on the practitioner. This is the force from the harness that is applied around the waist or hip. This force contributes to an increased flexion moment around the hip and an extension moment around the knee, which probably makes the muscle recruitment pattern different from many other similar sports. This scenario is possibly activating the posterior muscles of the lower extremities more than for example snowboarding. This course of event is most likely also the same in sports like wind surfing and wakeboarding.

The manufacturers within the kiteboarding industry are constantly moving towards better and safer products, and are working a lot with product development. For being able to develop products in line with ergonomic guidelines is important to give them a scientific background of the sport and its biomechanics. This ought to be helpful while deciding what is worth focusing on for making the products user friendly, safe and with minimal negative effects on the body.

Since earlier studies mainly have looked into the trauma injuries, and concluded that an enhancement of the safety systems and the safety thinking of kite surfing is needed, it is time to go deeper into biomechanics of kite surfing. Optimization of performance demand better physical preparation and development of equipment.

This project will hopefully conduct to a better understanding of the biomechanics of kite surfing, enhancement of the equipment and less injuries on the water.

6 References


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