DEVELOPING TEXTILE BIOFEEDBACK TECHNOLOGY: FROM BRASSIERES TO NOISY KNEES

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INTRODUCTION

A perpetual challenge confronting practitioners when they are evaluating and modifying human motion is to monitor the kinematics and/or kinetics characterizing human performance in the field and then to "feed" this information back to the performer in real-time so the performer can modify their motion to achieve the desired outcome. Although advances in technology have provided highly sophisticated equipment for biomechanical analyses of human performance, many of these items are unsuitable as biofeedback devices because they require extensive data processing before meaningful information can be relayed back to the performer. Other devices, particularly those attached to an individual's body, are often inappropriate as they have rigid components that do not conform to the individual's body shape, thereby interfering with their natural motion during performance of a movement and possibly posing a safety hazard.

Recent advances in polymer science, however, now enable inherently conducting polymers to be integrated into appropriate host fabrics, creating the opportunity to develop wearable sensors which offer novel biomonitoring options. These fabric sensors, with strain gauge-like properties that have a wide dynamic range, are ideal for biomonitoring applications as they can be integrated directly into existing clothing and equipment without changing the material properties or functions of these items and without interfering with normal human motion. When connected to appropriate electronic circuitry, these fabric sensors can also act as unique wearable systems capable of providing biofeedback to the wearer with respect to their joint motion. The purpose of this talk is to overview the development of these unique fabric sensors, from their initial application in monitoring breast motion to the development of an innovative fabric biofeedback system designed for use in landing training programs to reduce the rate of non-contact anterior cruciate ligament (ACL) ruptures.

WHY MONITOR BREAST MOTION?

As female breasts have limited internal anatomical support, external support, such as a sports brassiere, is usually recommended to reduce breast motion and, in turn, exercise-induced breast pain, during vigorous activity. Breast motion is restricted by compressing the breasts tightly against the chest wall and by using relatively non-elastic materials in the vertical plane. Although effective in limiting breast motion and related breast pain, the straps of most current sports bras bear much of the load generated by breast motion during physical activity. Excessive brassiere strap loading can lead to a distinct set of symptoms including deep brassiere strap furrows, malpostures and paresthesias of the fifth digit [1]. Despite potential negative consequences associated with excessive strap pressure, no research was located quantifying the loads borne by brassiere straps during physical activity. A novel method using inherently conducting polymers to directly measure dynamic brassiere strap loading during treadmill running was therefore developed and will be described.

NOISY KNEES?

Non-contact rupture of the ACL is one of the most common disabling injuries an athlete can sustain. As ACL rupture frequently results from poor landing technique, it is postulated that learning to land correctly, particularly bending the knee sufficiently, can help to protect athletes against non-contact ACL injury. The "Intelligent Knee Sleeve" (IKS) was developed, also using polymer technology, as an immediate biofeedback system to teach athletes how to land correctly. The IKS consists of a simple, inexpensive sleeve of Lycra-like material incorporating a disposable polymer coated fabric sensor that is placed over the patella. The fabric sensor, integrated into an electronic circuit, acts as a fabric strain gauge whereby as the sensor is stretched when the wearer bends their knee, resistance within the sensor decreases. At a predetermined threshold resistance, which can be varied, an audible tone is emitted to alert the wearer that the desired knee flexion angle has been achieved. The knee sleeve has the advantage over other currently available feedback devices of providing immediate individualized feedback to the wearer, thereby increasing the objectivity, frequency, and speed of feedback. How the IKS was developed and how it is used as a biofeedback system to teach safe landing technique will be described. Future applications of fabric biofeedback systems in enhancing patient rehabilitation following total knee replacement surgery will also be presented.

Figure 1: An early prototype of the Intelligent Knee Sleeve.

REFERENCES

1. Letterman G, Schurter M. *Ann Plastic Surg* 1980; 5(6): 425-431.

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