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Abstract

Background: The physiological tremor consists in an involuntary oscillation of the limbs, in the range of 10 Hz, which is generated in part from supraspinal brain structures. Its quantitative assessment in the sport science is relevant for sports requiring ability and for the assessment of fatigue. However, the measurement of tremor is not yet entered in standard sports medicine practice because expensive and complex instrumentations are needed. We present a simple, compact and cost-effective device for tremor measurement, based on the remote of the Wii console, the Wiimote, a wirless triaxial accelerometer which can communicate via bluetooth with a personal computer.

Materials and Methods: Eight male healthy volunteers were asked to maintain with the dominant hand the Wiimote pointing a fixed target for for a minimum of 90 seconds. The conversion of bluetooth data sent by the Wiimote in a final file containing the accelerometer informations has been obtained using a custom script in GlovePie environment. The analysis of the predominant frequency band was done in R environment. We then demonstrated the sensibility of the Wiimote to the modification of tremor induced by a muscular exercise, analyzing tremor after 20 repetitions, at the maximum velocity of full range elbow extension/flexion exercises. Moreover, we compared the analysis of tremor using the Wiimote with two other widely used approaches, spiralometry and laser pointing.

Results: Using the Wiimote it is possible to get a real time feedback on hand tremor. The sampling rate was sufficient to observe the frequency peak at 8-10 Hz, which characterizes postural tremor and the increase of tremor intensity after the exercise. Moreover the Wiimote largely outperformed the spiralometry and laser pointing system.

Conclusions: The Wii remote application represents an accessible and simple way for clinicians to quantify tremor which might easily become part of the standard toolkit for scientists and sports medicine professionals.

Keywords
Tremor – precision – frequency analysis – accelerometers

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A new method for quantitative tremor assessment in sports

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Introduction

Small involuntary oscillations in distal parts of the limbs characterize the activities requiring position holding. These oscillations are defined as physiological tremor. The frequency content of these oscillations reflects the mechanical resonance of limb segments [5] and superimposed loads, so that proximal segments resonate maximally at 2-4 Hz, [29] and distal ones at 20-30 Hz [38]. The origin of the oscillations depends on different mechanisms: (i) the cardiac activity induces lower frequencies; (ii) the spinal cord and the stretch reflex impinges on other frequencies [23]; (iii) the brain structure above the spinal cord characterizes the oscillations at 8-12 Hz or above (Piper rhythm) [21].

Previous observations showed the importance of tremor measurement for sports where the precision of movements is pivotal, such as in pistol shooters [36] and archery [34]. It is also important for the assessment of muscle exertion [1]. Moreover it has important clinical value because many pathologies have greater tremor amplitude at specific frequency bands. However, although only limited data are available, it is likely that tremor intensity has also some relevance in the performance of other sports, especially because there is a relation between tremor and muscle fatigue [24].

Several methods have been proposed to quantitatively assess tremor. Among these, the use of accelerometers and condenser microphones [15], electromyography [2], lasers [3], mechanical devices [22], or drawing spirals on digitizing tablets [16] have been described.

At present, the most widely used technology is the triaxial accelerometer because it is inexpensive, sensible, flexible and reliabile. Previous authors have even proposed to use the accelerometers of mobile phones to measure tremor [13].

Here we present a simple and cost effective solution, based on the Wiimote, a device hosting a triaxial accelerometer and a wireless communication protocol. Previous independent studies reported the reliability of this instrument to measure oscillations and its possible application to measure pathological tremor [7,20].

We present data for the implementation and use of the Wiimote in physiological tremor detection and its quantification, and for the analysis of the predominant frequency band. We show that the instrument is also sufficiently sensible to indentify muscle fatigue after muscle exertion. The application can represent

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Eine neue Methode für die quantitative Tremor Beurteilung im Sport

Zusammenfassung

Hintergrund: Der physiologische Tremor besteht in einer unwillkürlichen Schwingung der Gliedmaßen im Bereich von 10 Hz, die zum Teil aus supraspinalen Hirnstrukturen erzeugt wird. Die quantitative Bewertung in der Sportwissenschaft ist für die Sport-Fähigkeit erforderlich und für die Beurteilung der Ermüdung relevant. Allerdings ist die Messung des Tremors in der Seriensportmedizin noch keine Praxis, weil teure und komplexe Instrumente erforderlich sind. Wir präsentieren eine einfache, kompakte und kostengünstige Vorrichtung für die Tremor Messung, basierend auf der Fernbedienung der Wii-Konsole, der Wiimote, einem wireless dreiachsigen Beschleunigungsmesser, der über Bluetooth mit einem PC kommunizieren kann.
Material und Methoden: Acht gesunde, männliche Probanden wurden aufgefordert, mit der dominanten Hand auf die Wiimote zu zeigen für ein Minimum von 90 Sekunden. Es erfolgt die Umwandlung von der Wiimote in eine Datei, die die Beschleunigungsinformationen sendet. Bluetooth- Daten wurden mit einem benutzerdefinierten Skript in der GlovePIE Umwelt erhalten. Die Analyse des vorherrschenden Frequenzbandes wurde in einer R-Umgebung durchgeführt. Wir haben dann gezeigt, dass die Sensibilität der Wiimote die Veränderung des Tremors durch eine induzierte Muskelübung, die Analyse des Zitterns nach 20 Wiederholungen, bei der maximalen Geschwindigkeit der vollständigen Palette Ellbogen Extension / Flexion Übungen aufzeigt.Außerdem verglichen wir die Analyse des Tremors mit der Wiimote mit zwei anderen weit verbreiteten Ansätzen, spiralometry und Laser-Zeigesystem.
Ergebnisse: Mit der Wiimote ist es möglich, ein Echtzeit-Feedback zum Zittern der Hand zu bekommen. Die Abtastrate war ausreichend, um die Frequenzspitze bei 8-10 Hz, den Haltetremor und die Zunahme der Intensität des Zitterns nach der Übung zu beobachten. Darüber hinaus ist die Wiimote weitgehend besser als das spiralometry und Laser-Zeigesystem.
Schlussfolgerungen: Die Wii-Remote-Anwendung stellt eine einfache Art und Weise dar, um Zittern zu quantifizieren und die Teil des Standard-Toolkits für Wissenschaftler und Sportmediziner werden könnte.

Schlüsselwörter
Tremor – Präzision – Frequenzanalyse – Beschleunigungsmesser

an accessible way to quantify the tremor in sport studies.

Materials and Methods

Subjects

Eight male healthy volunteers (age 26 ± 6.7 years; height 189 ± 13 cm; weight 86.2 ± 17.9) participated in the study. Subjects were asked to avoid caffeine intake for at least 2 h before the experiment. The informed consent, as approved by Ethical Committee of the University of Molise, was obtained prior to testing.

Tremor recording

The hand tremor was recorded in all subjects who were seated comfortably in an armchair, with the dominant arm completely extended, the forearm and wrist in prone position. The dominant hand was supporting the Wii Remote (Wiimote, nominal weight of 288gr with batteries inside). Subjects were instructed to point a fixed target with the remote, holding the hand as still as possible for a minimum of 90 seconds (only 60 continuous seconds in the middle were then used for the analysis). The Wiimote is a wireless controller hosting a triaxial accelerometer, an infrared webcam, and a triaxial gyroscope, which can send informations using a standard bluetooth device. The connection of a PC-based Windows system to the Wiimote has been obtained using the BlueSoleil Bluetooth stack. Conversion of bluetooth data in a final file containing the accelerometer informations has been obtained using a custom script in GlovePie environment, attached at the end of the article (see also Fig. 1A-C). The acquisition rate was 100 Hz.

Muscular exercise protocol

To demonstrate the sensibility of Wiimote accelerometers to a muscular exercise, subjects were required to perform a series of full range elbow extension/flexion exercises with their dominant limb. Each person carried out 20 repetitions, at the maximum velocity, using a load set at 10% maximal voluntary contraction (MVC) of the elbow flexor muscles (measured in isometric conditions with a force transducer). This intensity was chosen in order to mimic real-life situations during sports. Immediately after the exercise, the tremor intensity was measured with the protocol described above.

Recording of tremor using alternative methods

We have used two additional standard techniques to assess the tremor, namely spiralometry [16] and laser-oscillation [3].
For laser tracking, we used a protocol detailed in a previous work [27]. Briefly, subjects were required to center a small circular target using the light emitted by a small laser pointer, and to maintain the position for one minute. The target was three meters apart. The oscillation of the laser pointer was measured by videorecording the position of the laser light on the target. Recording was accomplished with a digital camera having a frame rate of 60 Hz and a resolution of 640 x 480 pxls. The movies were then tracked using ImageJ software (http://rsb.info.nih.gov/ij/) and the tracking plugin.
For spiralometry, the method was slightly modified from that detailed in a previous work [28]. Briefly, subjects were required to follow the trace of an Archimedean spiral on a digitizing tablet (Logitech). The movements of the writing pen on the tablet were collected using a custom script in Glovepie environment. The spiral drawings were then