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Performance Analysis in Strength Training: An Innovative Instrumentation

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Abstract

In strength training, the performance of the athletes varies according to different objectives of the training. In this study, the performance of the athlete in strength training is defined as the torque and power generated to lift given loads. Electromyography (EMG) is utilized during the performance assessment to prevent muscle injuries. Over the past few years, athletic and clinical testing on performance analysis and enhancement have traditionally taken place in the laboratory due to the low portability of the equipment. With the rapid development in electronics miniaturization, instrumentation for such data acquisition can be constructed in mini and micro scale. Miniaturized instrumentations are designed to be unobtrusive to athletes' movement during performance analysis and enhancement. On the other hand, the correlation between muscle activity and real-time data for performance assessment is critical for coaches and physiologists. With the aid of a miniaturized system that can correlate the muscle activity with performance, fatigue, impulse and total energy expenditure, coaches and physiologists can plan the most suitable training for athletes to achieve higher performance. In conclusion, this study focuses on the miniaturized instrumentation for the analysis of athletes' performance in strength training.

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Keywords: Strength Training, Performance Analysis, Instrumentation, EMG, Muscle Fatigue

1. Introduction

Strength training is a type of exercise that specializing in using resistance to induce the muscular contraction which helps to build the strength, anaerobic, and size of skeletal muscles.[1]

Sports, where strength training plays a vital role, are for instance bodybuilding, weightlifting, powerlifting and javelin throw. Other notable sports that also uses strength training as part of their training regimen are American football, wrestling, rugby, track and field, rowing, lacrosse, basketball, pole dancing (or pole fitness) and hockey. Strength training is becoming increasingly popular for other sports and physical activities.[2] Hence, performance analysis of the athlete becoming a vital part of maintaining the condition of the athlete. Performance Analysis is an approach that involves systematic study to improve the performance and decision making, primarily presented through the provision of data analysis or visual feedback.[3,4]

To gather data more efficiently, instrumentation plays an important role. Instrumentation is an approach that comprises the development of the instrument to measure physical quantities for monitoring, control and observation.[5] Currently, hand–held, personal digital assistance (PDA)-based physiological data acquisition systems have progressively become more common in daily applications due to their portability, decreasing price, enhanced product performance, robustness, signal accuracy, lesser

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weight and extensibility.[6] In sports, there are a number of commercial systems available for measuring muscle disorder, muscle strength, biofeedback muscle stimulation, monitor the exercised segment peak velocity and other sporting concerns.[7]

Electromyography, which is also known as EMG, is an electrodiagnostic technique for evaluating and recording the electrical activities that produced by skeletal muscles.[8] Some critical features from well-known EMG system vendors include real-time visualization of results, connection to a computer and a sensor, portability, PDA-based user-friendly software with visible GUI, low cost, usage capability in different parts of the body.[9] Previous work reflects the importance of the features above in the design of both portable and non-portable physiological monitoring devices. Burns et al. developed a wireless physiological signal monitoring system with EMG and ECG sensors for monitoring human movement and sleep, the device can be operated both by a desktop computer and a mobile phone. Hand-held physiological monitoring system demand is growing, however, research in that area is much to be desired.

Meanwhile, the intensity of the training is also a critical factor that may lead to muscle fatigue.[10] Muscle fatigue is the inability of the muscle to generate force and to maintain the contraction to carry out high-intensity training.[11,12] Recent studies suggested that linear acceleration, which can be measured by accelerometer or Inertia Measuring Unit (IMU) can be defined as the intensity of training.[5] Linear acceleration data collected through IMU can be a valuable information for the coaches to monitor the performance of the athlete.[13]

This papers proposed an instrumentation approach for monitoring the performance of athletes for free weight weightlifting by using a combination of Inertia Measuring Unit and EMG Sensor.

2. System Overview

This prototype system consists of a smartphone, a computer and two types of wearable sensors. In such setting, the smartphone serves as the hub for collected data from accelerometer real time and computer act as the device to gathered EMG data before both data are processed offline on the computer. Additionally, such setting allows transfer of data and processed results that enable real-time supervision of the training by rehabilitation specialists or personal trainers.

A 6 degree of freedom accelerometer was mounted on the dumbbell. The sensors sample the acceleration data with a sampling frequency of 100 Hz in order to prevent the sensors from experiencing overheat. Meanwhile, a Shimmer EMG sensor has been attached to the subject where the electrodes were attached at the Biceps of the subject to measure the muscle activities as shown in Fig 1.

All sensors were mounted by using standard sports equipment, such as Velcro strap. The installation of these sensors is relatively low-cost as compared to existing equipment. Furthermore, the attachment of the sensors does not obstruct the training in any way.

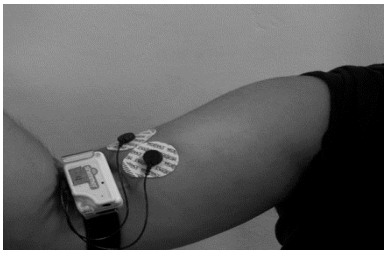

Fig 1. Attachment of Electromyography Sensor's Electrodes to the Bicep of the subject.

3. Methods

3.1. Participants

Three undergraduate male students of the age of 23 years old participated in the study. All three participants had prior strength training experience with the dumbbell during basketball team workout. The subject characteristic is presented in Table 1.

Table 1. The characteristic of the participants for the experiment.

Characteristic	Info
Gender	Male
Numbers	3
Age (years)	23
Height (m)	1.72 ± 0.09
Weight (km)	75.4 ± 8.4