Acquisition of Multiple Physiological Parameters During Physical Exercise

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ABSTRACT

This paper describes the experimental method focused on the acquisition of various physiological parameters during different effort levels of physical exercise like walking and running at several velocities. The study involved 57 young and adult people, 43 male and 14 female (24,37±5,96 years), from which 48 were soldiers belonging to the Infantry Regiment n.° 13 (RI13) of the Portuguese Army and 9 were teachers or college students of Sport Sciences, physically active but not competitive. The experimental measures provide a set of information that offers insight about the health status and physical performance of the subjects during exercise. This experimental method procedure is suited for the acquisition of physiological parameters with both the wireless physiological data acquisition systems such as the bioPlux and the respiratory analyzer gas systems such as Cosmed K4b2. The data was collected to allow the definition of a model that will be used to estimate the energy expenditure of a subject using a wireless physiological data acquisition system, which is much more comfortable and suitable to monitor physical exercise in everyday use than the standard method that makes use of a respiratory gas analysis system.

Keywords: Acquisition System, Experimental Method Procedure, Physical Activity, Physiological Parameters, Sensors

INTRODUCTION

The level of daily physical activity has a strong effect on a person’s quality of life and health. During the last decades, sedentary and inactive lifestyles have raised serious concerns regarding public health, with diseases such as cardiac illnesses, diabetes, obesity and others receiving a strong concern focus, as it is estimated by the World Health Organization (WHO) that obesity alone is responsible for 6% of the health budget of the European nations (WHO, 2006). The industrial development and its employment growth have in general significantly reduced...
the physical activity of the active population and the technological development has also allowed the increased number and increased degree of sedentary life styles (Laggeros & Lagiou, 2007). A significant part of the active population in developed countries lead a life with little or no physical activity and its leisure time is often occupied with sedentary activities like reading, surfing on the Internet, playing computer games, watching television, among others.

Currently there are a number of devices who assess the physical activity of an individual, for example the ActiGraph Activity Monitor (ActiGraph, 2010) or the RT3 Accelerometer (Stayhealthy, 2010). The goal of these devices is to monitor whether a person is fulfilling his/her amount of daily exercise or not, and to raise alarms if the foreseen levels are not met.

Taken to a next level, the evaluation of the physical activity level of a person has its roots in the need to determine if his/her physical activity behaviour falls within an interval or profile defined by a health care provider, using appropriate personalized criteria, with the objective of maintain or improve his/her health status. It is well known that physical activity reduces the risk of various diseases and brings several benefits, including improved glucose metabolism, reduced body fat and lower blood pressure (Choi et al., 2005).

The goals and expected benefits of physical activity monitoring, underline the importance of the acquisition of physiological parameters during exercise.

However, until very recently, it was difficult to get a set of physiological data using several measuring devices that are typically in different locations, some of them causing discomfort to those who use them, many of these having an associated cost of ownership and or operation that are not compatible to the desirable goal of enlarging its use to a broad sector of the population, thus rendering impracticable its use in Assisted Living solutions.

There are several methods and techniques to estimate the energy expenditure and the physical activity level of a subject. The techniques of direct calorimetry, indirect calorimetry and doubly-labeled water are considered the most precise methods for measuring the level of metabolism. Direct calorimetry measures the energy expended by assessing the rate of body heat lost to the environment, through either aerobically or anaerobically forms, and is held in chambers. This method has some disadvantages such as its high cost, the need for a long experimental time and the need for an artificial controlled environment, which is impracticable as part of a daily routine. Doubly-labelled water is one of the methods considered as “gold standard” for determining the energy expenditure (Murphy, 2009). It consists in the ingestion of water labelled with deuterium and oxygen isotopes. The measurement of the concentration of these elements in excreted urine and exhaled air enables the calculation of the energy demand by the organism of that subject. Its high cost (Littlewood et al., 2002) and the need for specialized personnel and equipment, has restricted its use in further studies. This method still has additional disadvantages since it only provides information on the total energy expenditure, and cannot be accurately used to monitor a subject in a small time interval. Moreover, the method gives no information about the type, intensity and duration of physical activity (Yamada et al., 2009). Thus, the de facto “gold standard” for the assessment of physical activity is the analysis of respiratory gases by indirect calorimetry (Choi et al., 2005). The respiratory gases, in particular, the production of gases such as carbon dioxide (CO$_2$), is a good indicator of the amount of metabolic activity going on in the cells, because this gas is a direct result of oxidation processes. Oxygen consumption and carbon dioxide release is measured and the Respiratory Exchange Ratio (RER) is calculated to establish which type of food is being oxidized. It is assumed that each food type releases a given amount of energy for each liter of oxygen consumed, and that the body’s oxygen and carbon dioxide contents remain constant. Total energy expenditure is estimated from the RER and from total oxygen consumption (Littlewood et al., 2002). The Cosmed K4
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