TECHNOLOGICAL DEVELOPMENTS IN HEALTH CARE
AND EXERCISE SCIENCES

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Abstract—State of the art technology is widely used in health care and exercise sciences. The use of such technology is based on availability and mainly by cost. Current devices are light, small and portable to allow health care practitioners provide accurate diagnostic tools for effective patient treatment. Software and apps such as video games for health are embedded in cell phones and tables, making them available to everyone. Knowledge and use of these devices is not limited to the highly skilled technicians, but rather to patients and common people of all ages. Miniaturization and nanotechnology allow exploring the human body and to collect data in real time. Microrobots seem to integrate technology, miniaturization and nanotechnology; therefore, these particles will extend their applications to health care and other fields like sports. These technologies are used in combating not only diseases such as cancer, but also in sports and exercise science research to provide athletes and staff with the latest instrumentation to achieve the best performance. New materials and devices will also help athletes recovering from injuries and return to play sooner. Next technological developments will include positive key features such as portability, miniaturization, automatization, and power sustainability. They are also challenged to overcome negative features like ethics, high cost, and access to the population.

Keywords—Health care, exercise science, nanotechnology, miniaturization, portability.

I. INTRODUCTION

Technology can be defined as a set of techniques, skills and processes used in the production of goods or services to fulfill a goal. Common ways to observe applied technology are machines, computers, devices and factories. Most people are often challenged to operate or use several technological devices without proper instruction. However, with new advancements in miniaturization and portability, most people are able to use technology properly without serious negative consequences. The learning curves for most new devices are short thanks to self-explanatory instructions and intuitive use. Devices and persons are tailored to work together in health care and exercise science settings. The aim of this manuscript will be two-fold: a) to show and discuss new technology in health care, and b) to show how technology is used in exercise science.
II. TECHNOLOGY IN HEALTH CARE

Technology has become the new allied in the diagnosis and intervention of known and newly discovered diseases and medical conditions. Scientists and technicians are currently working in designing, developing and testing new devices to facilitate patients to overcome their health problems and improving quality of life. New technology will provide deeper knowledge and better understanding of human anatomy and physiology that is needed to understand the complexity of the human systems.

Assessing cardiovascular structure and function is imperative to provide a better diagnostic to the patient/client. Portable or wearable technology (e.g., electrocardiogram) is becoming more popular among health care providers because is less time-consuming, accurate and friendlier to the patient (Mecnika, Kviesis-Kipge, Krieviņš, Marcnikevics, & Schwarz, 2013; Shih et al., 2015). Photoplethysmography (PPG) is an example of telemetric systems for biometry based on smart textiles, by which the measuring technique is based on an optical detection of tissue blood pulsations from the head (temporal artery), hand (1st phalange of the forefinger), wrist (radial artery) and neck (external carotid artery) (Mecnika et al., 2013). Along with the device, a program (i.e., software) is responsible for capturing, monitoring, processing and storing the data to help scientists interpret and recommend, for instance, a treatment or follow-up.

The concept of using one or several devices to measure different variables in a single person is referred to as integrated technology (IT) (Dellaserra, Yong, & Ransdell, 2014). IT is becoming more used today, since most new devices are small and portable; however, some limitations relate to scalability issues, cost, and the inability to receive signals within indoor environments (Dellaserra et al., 2014). Nevertheless, IT will be able to integrate several smaller devices and programs in a near future.

The possibility for creating machines or devices is important for technology; however, programming or software development is also imperative in health care. Devices such as cellular phones and tablets are created from electronic pieces that will work only after a computational program, an operating system or an application (App) makes them work (Pongpisit, Sineerat, & Therdpong, 2015). Moreover, software updates are sold for the already installed and fully functional device. This means that software developers are becoming extremely important professionals for the health care system.

A niche related to technology and programming has been recently developed, video games. These video games applied to health care are sometimes called “serious games” (Encarnação, 2010). This is a term reflecting different aspects of video game design, development, hardware and game play, in which it is expected a measurable impact on the player’s health without the player necessarily being aware of the intended impact (Encarnação, 2010). Software developer research is currently published in specialized journals (e.g., Games for Health Journal), where games are experimentally tested on different populations, for instance, in stroke survivors and heart disease patients (Casserly & Baer, 2014; Dithmer et al., 2015). It is important to notice that virtual reality and video games in general, are considered an important revenue enterprise, with billions of dollars spent every year by consumers worldwide.

Portability is a key in the health care industry. Smartphones are small and portable and they are considered both, a blessing and a curse. A blessing because they provide the opportunity to constantly reach significant others (i.e., family, friends), and a curse, because they might promote sedentary behaviors (e.g., video games). A systematic review studied the evidence on smartphones and their viability for measuring and influencing physical activity (Bort-Roig, Gilson, Puig-Ribera, Contreras, & Trost, 2014). Evidence suggest that the novelty of using smartphones to promote physical activity and the engaging intervention strategies, as well as the positive user perceptions on their usefulness and viability, make smartphones potential allies to fighting sedentary behaviors. In addition, smartphones and other portable devices such as tablets are used not only indoors but also outdoors in the field (Lee et al., 2015). For instance, a review was published regarding the apps used to recognize and assess sports concussions. The main finding was that some apps were inappropriate given their content for different groups of end users (Lee et al., 2015). Therefore, careful attention must be paid when using apps in smartphones and tablets.

Nanotechnology (NNT) is among the most recent applied science to health care. With more than 15 years of research and development (Heath, 2015), NNT is a blend of science, engineering, and technology conducted at the nanoscale (i.e., about 1 to 100 nanometers). Just for reference, a sheet of newspaper is about 100,000 nanometers thick. This means that this technology can be used and it is currently used for health care. For instance, NNT has...
been suggested for psychiatric (Fond, Macgregor, & Miot, 2013; Fond & Miot, 2013) use and it is currently being applied to several forms of oral cancer (Calixto, Berengossi, Fonseca-Santos, & Chorilli, 2014), skin treatments (Antonio, Antonio, Cardeal, Ballavenuto, & Oliveira, 2014), blood (Ilinskaya & Dobrovolskaia, 2013), eye (N. J. Kim et al., 2014), rheumatologic and immune diseases (Henderson, Madison, & Shah, 2014).

Miniaturization is another feature of technology as applied to health care (Martel, 2012). Microrobots are currently being developed to “swim” inside the human body (Peyer, Zhang, & Nelson, 2013). Science fiction novels such as “Fantastic Voyage – 1966” might have provided the ideas to develop such technology. In the novel, a scientist is nearly assassinated, and in order to save him, a submarine is shrunken to microscopic size and injected into his bloodstream with a small crew. Problems arise almost as soon as they enter the bloodstream. Almost 50 years later, scientists are starting to use technology to embark in biomedical applications such as minimally invasive procedures, targeted drug delivery. In order to accomplish these goals, researchers are trying to mimic bacteria (e.g., *E. coli*) for microrobot propulsion (Martel, 2012; Peyer et al., 2013) (Figure 1).

![Figure 1](image.jpg)

**Figure 1.** The use of bacteria to understand microrobot technology applied to health care.

Source: Adapted from (Peyer et al. (2013), p.1261)

III. TECHNOLOGY IN EXERCISE SCIENCES

The term “accuracy” refers to the closeness of a measurement to the true value. Research of any type requires extremely accuracy to obtain a true value of a variable or a characteristic being measured. For instance, electronic scales provide more accurate values than analog scales; however, mechanical parts last longer than electronic parts. Therefore, there is a debate on what would be the best device to work with. The focus of this section will be on how technology has been used in exercise sciences and it has improved research accuracy in this field.

Sedentary time is closely related to several diseases, including obesity, hypertension, diabetes and some forms of cancer (American College of Sports Medicine, 2014). Several attempts have been made to increase physical activity
in the population. Therefore, monitoring physical activity is important for exercise prescription. Thus, it follows that for a health care practitioner it is necessary to determine the level of physical activity of a patient/client. This information can be obtained in different ways, for instance, by means of questionnaires (Booth, 2000). However, the accuracy of questionnaires is low, and objective measures are preferred. Accelerometers have been used to obtain more accurate measures of physical activity (Kanitthika, Soochan, Kaewkannate, & Kim, 2016). Four wearable devices were studied to determine their accuracy. In the experiment, participants wore the four devices in their wrist and the accuracy after testing was determined (Kanitthika et al., 2016). The results of the study indicated a high accuracy of the devices, ranging from 92.4% to 99.9% for indoor walking straight, walking up/down stairs, and for walking on a treadmill (Kanitthika et al., 2016). It is important to recall that accelerometers are the newest versions of the old pedometers, which worked on mechanical rather than on electronic components.

The use of technology is common in most sports (Coris, Zwyygart, Fletcher, & Pescasio, 2009; Dellaserra et al., 2014; Laferrier et al., 2012), even when some criticisms have been made against its use (e.g., Oscar Pistorius’ transtibial prostheses) (Burkett, McNamee, & Potthast, 2011). For instance, the use of magnetic resonance imaging, ultrasound, and 3-dimensional reconstruction computed tomography (3-D CT) has become popular for clinicians and sports medicine professionals (Coris et al., 2009). These devices and techniques provide better and accurate images to support interventions aimed to diagnose, intervene, and rehabilitate injuries. Therefore, athletes are able to return to practice and competition in shorter time.

Technology has also shown to improve Olympic records (Balmer, Pleasence, & Nevill, 2012). For instance, in the sport event of pole vault, materials changed from rudimentary ash, bamboo, aluminum, to finally (?) fiberglass poles, providing athletes with lighter and more resistant poles. These new materials allowed athletes to set new records that eventually will be overcome with new materials and better pole vault technique.

A recent narrative-qualitative review (Dellaserra et al., 2014), showed that IT (i.e., accelerometers, heart rate monitors, GPS) are widely used in sports. The review included 114 scientific articles published from 1990 to the 2014, and the main categories for IT use were movement pattern quantification, assessment of the differences between demands of training and competition, measurement of physiological and metabolic responses, and determination of valid definitions for velocity and a sprint effort (Dellaserra et al., 2014). The use of such technology provides athletes and coaches with real time accurate measures for planning of training and competitions, and researchers with better control for their experiments.

Microtechnology has also allowed researchers to understand the locomotor demands of various physical activities (Cummins, Orr, O’Connor, & West, 2013). While wearable global positioning technology (i.e., GPS) has been used to quantify the locomotor demands of sporting activities, microsensors (i.e., accelerometers, gyroscopes and magnetometers) embedded within the units also have the capability to detect sport-specific movements (Chambers, Gabbett, Cole, & Beard, 2015). In a systematic review of the literature, positive evidence was found on the use of microsensors to quantify some movements (e.g., tackling within rugby union, rugby league and Australian rules football); however, authors suggest that it is required more studies to validate the ability of wearable microsensors containing accelerometers, gyroscopes and magnetometers to detect tackles in collision sports (Chambers et al., 2015).

Video game consoles are being modified to take advantage of their internal hardware and electronic components to study human motion (e.g., gait parameters, standing balance, postural control) (Clark et al., 2015; Mentiplay et al., 2015; Xu, McGorry, Chou, Lin, & Chang, 2015). Recently (A. Kim, Kim, Rietdyk, & Ziaie, 2015), used a cellphone and attached to it a camera-based system for measurement of spatiotemporal gait parameters, which provides valuable diagnostic and prognostic information, especially in the elderly. With the advent of new smart phones and tablets in the market, it is very likely that new attachments will be designed in a near future.

The most novel developments for technology applied to sport science research are inventions using NNT. This technology has been recently used, for instance, in the detection of prohibited substances in sports (i.e., doping control) (Thomas, Walpurgis, Krug, Schanzer, & Thevis, 2012). Also, with a plethora of mobile devices, energy or power management to make these devices run has become critical. Recently (Niu, Wang, Yi, Zhou, & Wang, 2015), designed a self-charging power system for sustainable operation of mobile electronics. This device uses exclusively human biomechanical energy, and consists of a high-output triboelectric nanogenerator (TENG), a power management circuit to convert the random alternating current (AC) energy to direct current (DC) electricity at 60%
efficiency, and an energy storage device (Niu et al., 2015). TENG technology may be used for sustainable power of other devices such as thermometers, electrocardiograph systems, pedometers, accelerometers, wearable watches, and perhaps, cell phones and tablets in a near future (Yang et al., 2013) (Figure 2).

Figure 2. Power sustainability from human motion. Source: (Niu et al., 2015), p. 6)

IV. CONCLUSION

Humans are constantly challenged to create new inventions to alleviate health problems and increase quality of life. Technology is a combination of creativity and opportunity. Sometimes cost prevent countries to access technology for their citizens; however, great ideas might come from poor countries. Today, technology is available to several populations in the form of telephone applications (Apps) and video games. The trained scientists and common people everywhere use technology, which is becoming more portable, requiring miniaturization, automatization, and power sustainability. Technology is used in all areas of knowledge, including sports, where athletes, coaches and medical staff benefit from nanotechnology and new materials, among others.

REFERENCES


