# Chapter 3
# Health and Fitness Wearables

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## ABSTRACT

*Health and fitness wearable technology has been around for about 45 years. The most common wearables initially included heart rate monitors, pedometers, and GPS systems. While most of these were initially available as stand-alone devices, many are now available in combination devices such as fitness trackers and smart watches. Health and fitness wearables are used in a wide variety of situations including sports, athletics, personal health, fitness, education, and medical settings. A brief history of each wearable is provided, basic functions are explained, selected research is presented, and potential future developments are discussed. Some information is provided regarding current models and features.*

## INTRODUCTION

This chapter provides an overview of wearable technology related to health and fitness. The focus is on the more common wearables including heart rate monitors, pedometers, accelerometers, and combination devices such as fitness trackers and smart garments. Some of the wearables discussed are devices and some are embedded devices. Research findings will be summarized and reviewed where possible. While some of the technologies have been heavily researched (such as pedometers), others – notably the newer technologies - have little if any research available.

## BACKGROUND

Health and fitness wearables have been used in many settings for many different purposes and with many different populations. The more common applications include personal use, educational, sports, athletics, medical use, and research. See Sultan, 2015, for an excellent review on the development of wearables and their use in healthcare and medical education. Bächlin and Tröster (2012) provide a comprehensive

review on health and fitness wearables, describing their use in a wide variety of sports including cycling, diving, running, skiing, snowboard, ski-jumping, golf, rowing, football games, baseball, and table tennis. A review of the research literature on each wearable is included.

## MAIN FOCUS OF THE CHAPTER

The objectives of this chapter are to provide an overview of the most common health and fitness wearable technologies including research findings as well as perspectives on the past, present, and future of these technologies and discussions of their applications. Issues, controversies, and problems, as identified in the research, are presented for each technology.

## HEART RATE MONITORS

There was a so-called "fitness boom" during the 1970s and 1980s when aerobic activities such as jogging and dance greatly increased in popularity. This was in part due to an increased public awareness of the benefits of aerobic fitness in terms of decreasing the risks for some of the leading causes of death including cardiovascular disease. Bill Bowerman, co-founder of Nike, Inc. and head coach of track at the University of Oregon, along with a cardiologist, published a book called "Jogging" in 1966 selling over a million copies and was credited with helping to popularize jogging in the United States. Another influential book helped start what some called "America's fitness revolution" and further popularized running for fitness. The book was titled "The Complete Book of Running" by James "Jim" Fixx, published in 1977 and sold over one million copies. Many aerobic exercisers were taught the recommendations for the intensity, duration, and frequency of exercise as specified by the American College of Sports Medicine. The basic indicator of intensity is exercise heart rate but there was a challenge for exercisers in that usually, the only way to determine the exercise heart rate was to take it manually. This was not a problem if one stopped exercising, but stopping was disruptive unless one was at the end of a workout. Taking a pulse rate manually during a workout was often very difficult, particularly during running or swimming. One alternative commonly used was to have exercisers rate their "perceived exertion". There was a formalized system for this known as Borg's Rating of Perceived Exertion (Borg, 1970). Researchers frequently investigated the system in an effort to determine if it was valid and reliable. Given that the Borg system was mostly subjective it was not an ideal way to assess the intensity of exercise. This state of affairs set the stage for the introduction of the heart rate monitor. Heart rate monitors are often used to determine the intensity of aerobic exercise. Specifically, they allow users to track their heart rate during exercise to aid in maintaining the appropriate intensity or workload. Most heart rate monitors work by combining electrodes to sense the electrical signal from the heart. In some cases this is augmented with an audio device detecting the sound from the heart. The first wearable heart rate monitors used a chest strap sending telemetry on the heart rate to a watch worn on the wrist. The chest sensors usually needed to have good contact with the skin and enough moisture for the electrodes to pick up the signal. During high intensity activity there was usually adequate perspiration to ensure a good signal provided the fit was snug, but users often had to moisten the back of the sensor to get good signal when first putting it on. With some of the new sensors such as those in the smart watches and those involving ear clip-ons, the moisture issue may no longer be a concern. The American College of Sports Medicine is one of the

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