TRACK IT

Validity and Utility of Consumer-Based Physical Activity Monitors

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LEARNING OBJECTIVE

From this article, the reader should learn about the progression of technology in accelerometry-based activity monitors as well as the characteristics and features in various consumer-based activity monitors.

Key words:
Consumer-Based Physical Activity Monitors, Self-monitoring, Fitbit, Basis Band, Nike+ FuelBand

INTRODUCTION

Accelerometry-based activity monitors have become the standard objective method for assessing physical activity in field-based research (1,5,8). They are small, noninvasive, easy-to use, and are well tolerated by research participants. The main advantage from a research perspective is that they provide an objective indicator of physical activity behavior — thereby avoiding common sources of error in subjective measurement (*e.g.,* self-report). Because of their storage data capacity, it is possible to monitor behavior across extended periods and easy to download the information to a computer for processing. Numerous studies (2,3,5) have been published on the reliability and validity of various accelerometry-based physical activity monitors, and these devices have become widely accepted in the field.

While still widely used in research, companies have now begun to target the larger consumer market. A variety of consumer-based activity monitors are now available for use by individuals and health professionals interested in fitness, health, and weight control. Some companies have adapted more sophisticated research-based devices to create lower-cost monitors that are easier to use, less expensive, and more marketable for consumers. These devices generally provide consumers and health professionals with the ability to estimate levels of physical activity by day and track data across time. Other companies have enhanced monitoring technologies to create more comprehensive and useful self-monitoring tools.

These technologies include pedometers and global positioning system (GPS) and heart rate (HR) monitors. Pedometers, for example, have been calibrated to provide other outputs such as intensity of activity and energy expenditure (EE). Memory and downloading capabilities also have been added to allow data to be stored across time. A number of other devices have been adapted in ways that enable them to track physical activity. GPS monitors are developed primarily for use to track expenditure from activity (4). HR monitors, originally marketed to athletes, have been modified and marketed to appeal to more recreational athletes interested in health and weight control and to more fitness professionals interested in personal training. A number of other new accelerometry-based devices have been developed to facilitate wear time and comfort. There are

devices designed to target an easy-to-wear concept to be worn on necklaces, in pockets, or on the wrist.

A variety of factors have contributed to the convergence of technology in this line of consumer-based activity monitors. One key contributing factor in this convergence is the significant advance in accelerometer technology. For instance, the use of accelerometers in mobile phone systems (*i.e.,* smartphone) led to increased demand for low-cost high-quality accelerometers, and this demand led to the increased availability of more powerful lower-cost accelerometer technology. Furthermore, most smartphones now come equipped with built-in accelerometers and GPS units so a number of cell phone apps also are available to monitor activity (*i.e.,* Moves). There still are a number of issues that must be resolved to capitalize on this capability fully, but the tremendous growth in the smartphone industry likely will spur on additional innovation and refinement of these applications.

Another key factor in the convergence of monitoring technology is the refinement of wireless data transfer such as Bluetooth technology. The standardization of USB ports led to some consolidation in communication methods, but the more significant advance has been the development of wireless data transfer and Bluetooth technology. Wireless technology has enabled monitors to download directly to a computer without the burden of cumbersome cables. The Bluetooth capability also enables data from monitors to be displayed directly on smartphones or portable computers. This feature has enhanced the user experience greatly and reduced the burden associated with downloading activity data.

A final factor in the convergence is the widespread acceptance of social media and data-sharing applications. New consumer-based monitors now commonly feature links to social media applications such as Facebook and Twitter to allow users to communicate and share progress. Other monitors feature integrated health coaching and associated text and email messaging services that provide prompts and feedback in real time. These features enhance the user experience and provide a way to promote accountability and social interactions.

The manufactures are competing actively to develop a functional and engaging monitor that provides the most seamless integration into a person's lifestyle. It is important for health and fitness professionals to understand how these monitors work and to evaluate them critically before endorsing or using them with clients or in promotional programs. This report provides brief summaries of the features of various consumer-based monitoring technologies. There currently are insufficient data on the validity of these competing platforms so the focus of this review simply is to highlight how they work and what they provide to prompt and promote physical activity behavior.

DESCRIPTION OF CONSUMER-BASED ACTIVITY MONITORS

For the health coach or fitness trainer, monitoring technology provides options for tracking health activities. Fitness professionals easily track their client's daily activity pattern with the Web site that is linked to the client's activity tracker and provide Web-based tailored physical activity advice. In addition, the fitness professionals create and send tailored messages to their client through the Web site or some of the linked Web sites provide auto-generated motivational messages. If the clients or consumers are achieving their planned activity goals, combining self-monitoring and online Web-connected tracking technology should prove effective in influencing physical activity. Features of eight different monitors are summarized below (in alphabetical order) as well as in the Table at the end of the article.

- **Basis B1 Band (Basis Science Inc., San Francisco, CA)**

The Basis B1 Band (Figure 1) is a wrist watch-style activity monitor with multiple sensors that integrate movement data from a three-dimensional accelerometer and magnitude (g-force) with various heat-related variables, such as skin surface temperature, ambient temperature, and galvanic skin response to estimate EE. The unique feature of the Basis band is its advanced optical sensing technology, which accurately measures HR and blood flow. The battery life in the Basis B1 Band lasts up to 5 days and is waterproof. In addition, it carries a digital watch all packed in an LCD touch screen interface.

- **BodyMedia FIT (BodyMedia Inc., Pittsburgh, PA)**

BodyMedia FIT (Figure 2) is a consumer version of a research-based accelerometer known as the SenseWear Armband. The SenseWear is a multisensor activity monitor worn on the upper arm as an armband. It integrates movement data from a three-dimensional accelerometer with various heat-related variables (*e.g.,* heat flux) and galvanic skin response to estimate EE. FIT uses the same technology as the SenseWear device but is designed to facilitate personal self-monitoring and weight control. The device comes with a watch interface and can connect wirelessly through Bluetooth with smartphone applications for data monitoring. The monitor has rechargeable batteries that can be used to collect and store data for 2 weeks. Data can be downloaded through a USB cable and viewed through a personalized Web-based software tool (ProConnect) to monitor results across time. The software also features an integrated tool for reporting calorie intake, which enables consumers to track energy balance and to set and monitor weight loss goals (the software interface also enables users to connect with health coaches for guidance and support).

- **DirectLife (DirectLife, Philips Lifestyle Incubator, Amsterdam, The Netherlands)**

The DirectLife (Figure 3) monitor is a triaxial accelerometer that uses the same technology as a research-based device — Tracmor. The DirectLife is a small (3.2 × 3.2 × 0.5 cm) lightweight (12.5 g) monitor that is designed to enhance wearability. It can be worn on the belt, attached as a necklace, or carried in a pocket. It also is waterproof to 3 m in depth. The DirectLife has a battery life of 3 weeks and an internal memory that can store data for up to 21 days. Data are downloaded directly to the Web site using a USB cable. The Web site provides users with an online health coach and personalized summary results.

TABLE: **Features of Consumer-Based Physical Activity Monitors**

	Basis B1 Band	BodyMedia Fit	DirectLife	Fitbit	Gruve	Nike+ FuelBand	Jawbone UP	PAM
Price	$199.00	$99.00	$199.00	$99.95	$109.95	$149.00	$129.99	$100.00
Monthly Web site access fee	Free	$6.95	$12.50	Free	$9.95	Free	Free	Free
Type	Watch style	Wearable	Wearable	Clip-on	Clip-on	Wristband	Wristband	Clip-on
Battery life	Multiple days	7 days	Up to 3 weeks	5–7 days	2–4 days	Up to 4 days	Up to 10 days	Up to 12 months
Water resistance	Yes	No	Yes	No	No	Yes	Yes	No
Monitor display	LCD touch screen	Display watch	Light	LED	Colored light	LED	No display	LED
Smartphone application	iOS, Android	iOS, Android	No	iOS, Android	No	iOS	iOS, Android	iOS, Android
Connection to dashboard	USB, Bluetooth	USB, Bluetooth	USB	USB, Bluetooth	USB	USB, Bluetooth	USB	USB, Bluetooth
Web display output and tracking metrics	TDEE PA time Steps Sleep time Heart rate Skin temp Perspiration	TDEE PA time Steps Sleep time Speed Distance	AEE PA time	TDEE PA time Steps Sleep pattern Distance Floors climbed	PA EE PA time	AEE PA time Steps Distance Points	TDEE PA time Steps Sleep pattern Distance	PA time AEE Points
Diet log	No	Yes	No	Yes	No	No	Yes	No
Prompt	Email	Email	Email	Email	Vibration	Email	Vibration	Email
Health coach	No	Yes	Yes	No	No	No	No	Yes

PA indicates physical activity; EE, energy expenditure; AEE, activity energy expenditure; iOS, iPhone operating system; TDEE, total daily energy expenditure.

- **Fitbit® (FitBit Inc., San Francisco, CA)**

The Fitbit (Figure 4) is a triaxial accelerometer that is designed to be clipped to a belt or waistband. The monitor is small (19.5 × 5.5 × 14 mm) lightweight (12 g) instrument that provides information about steps, stairs climbed, distance traveled, and calories burned. The battery in the Fitbit lasts 5 to 7 days and has an internal memory that can store data for up to 30 days. The function of wireless data transfer to the Web site does not necessitate connecting the monitor to the computer. The unique feature of the Fitbit is it provides information about sleep efficiency, but the study found that Fitbit (7) has high intradevice reliability and overestimates both sleep time and quality.

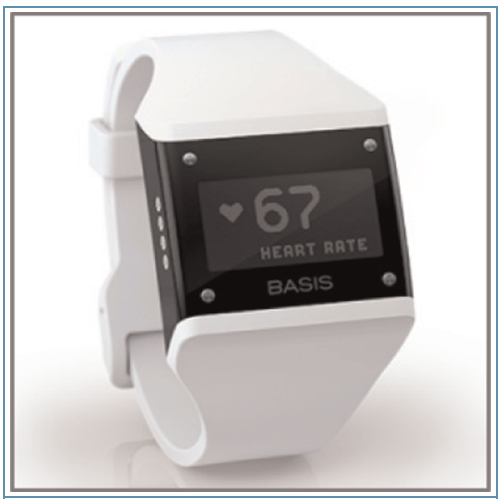

Figure 1. Basis B1 Band (Basis Science Inc., San Francisco, CA).

Figure 2. BodyMedia FIT (BodyMedia Inc., Pittsburgh, PA).

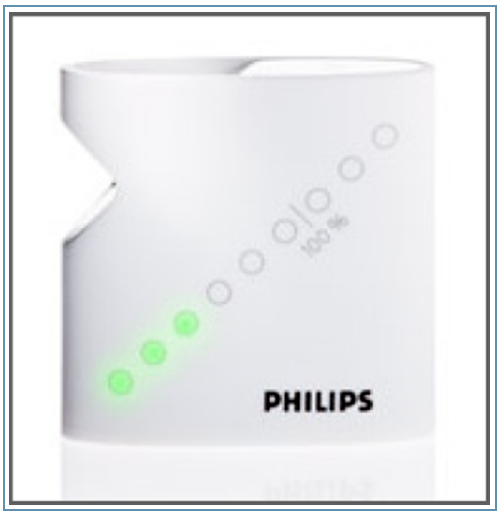

Figure 3. DirectLife (DirectLife, Philips Lifestyle Incubator, Amsterdam, The Netherlands).

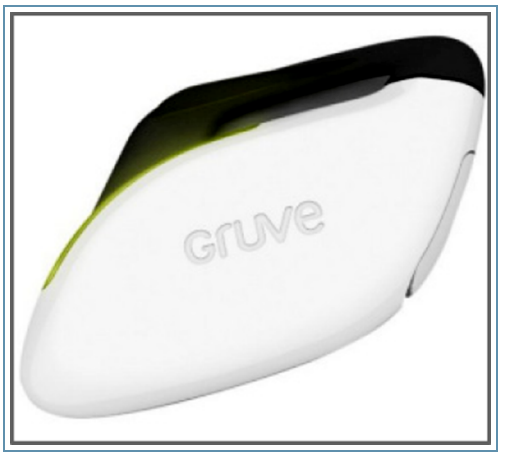

Figure 5. Gruve (MUVE Inc, Minneapolis, MN).

- **Gruve (MUVE Inc., Minneapolis, MN)**

The Gruve (Figure 5) is an omnidirectional accelerometer that can measure activity intensity, duration, and calories burned throughout the day. The battery in the Gruve lasts 3 to 5 days and stores data for up to 7 days. A unique feature of the Gruve is that the monitor vibrates to prompt users to move if they have been sedentary for 57 consecutive minutes.

- **Jawbone UP (Jawbone, San Francisco, CA)**

The Jawbone UP (Figure 6) band is a wrist-worn three-dimensional accelerometer that can measure sleep patterns, physical activity time, and food intake throughout the day. The UP band corresponds with an iOS device (iPhone 3GS or higher) via a 3.5-mm standard cable to synchronize data. The UP is water resistant up to 1 m and has a battery life span of 10 days. Comparable to the Gruve, the vibration function also is incorporated to prompt users to move.

- **Nike+ FuelBand (Nike Inc., Beaverton, OR)**

The Nike+ FuelBand (Figure 7) is a wrist-worn three-dimensional accelerometer, which assesses body movement, steps taken, distance, and calories burned. Data can be synchronized to the Nike+ Connect (Web site) via the clasp, which doubles as a USB cable or the accompanying application for an iOS device (iPhone) using Bluetooth. The FuelBand's battery life lasts up to 4 days, and the band uses a series of 100 mini-LED lights to provide a clear presentation of physical activity data (*i.e.,* steps, distance, and activity EE).

- **PAM (PAM BV, Doorwerth, The Netherlands)**

The Personal Activity Monitor (PAM) (Figure 8) is a small (5.8 × 4.2 × 1.3 cm), lightweight (28 g), triaxial accelerometer that builds on technology and coding from a previously validated one-dimensional monitor (9). The new PAM provides wireless communication with computer and Bluetooth links to smartphones (iOS and

Figure 4. Fitbit® (FitBit Inc., San Francisco, CA).

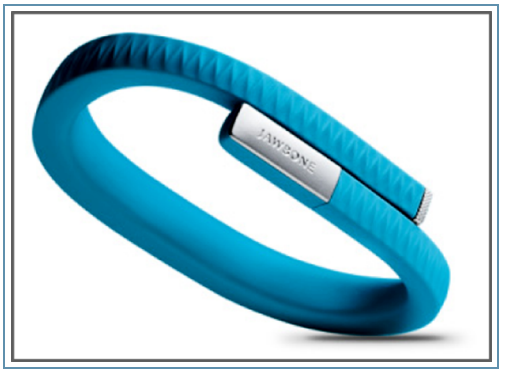

Figure 6. Jawbone UP (Jawbone, San Francisco, CA).

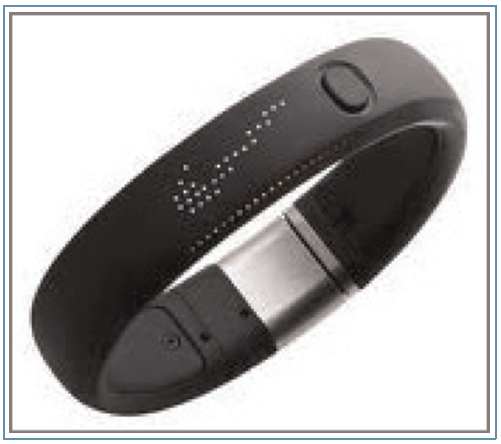

Figure 7. Nike+ FuelBand (Nike Inc., Beaverton, OR).

Figure 8. PAM (PAM BV, Doorwerth, The Netherlands).

Android) applications. The unique feature of the PAM monitor is that the battery life (*i.e.,* 12 months) of the PAM is far greater than that of other monitors. Data can be stored for up to 3 months.

CONCLUSIONS AND RECOMMENDATIONS

This article has summarized the progression of technology in accelerometry-based activity monitors as well as the characteristics and features of various consumer-based activity monitors. However, educators, researchers, fitness professionals, and consumers are encouraged to consider the relative importance of accuracy and practicality of the varying types of activity monitors when recommending or using a particular monitor. A monitor that is extremely accurate may not have utility if it is not functional or is cumbersome to use. A monitor also is of little value if it provides erroneous or highly inaccurate reports of activity (no matter how easy it is to use). This new class of monitors offers considerable potential to advance the science and practice of physical activity promotion. They can be a valuable tool to help individuals monitor their physical activity behavior given the training and support to help with adopting more active lifestyles.

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BRIDGING THE GAP

Consumer-based physical activity monitors allow individuals to track their daily physical activity objectively. Various types of these self-monitoring devices have been released into the market, and their underlying technologies have evolved drastically across recent years. Factors that have contributed to this convergence in consumer-based monitors include advances in accelerometer technology, the refinement of wireless data transfer, and the broad dissemination of social media and data sharing smartphone applications. The various classes of consumer-based monitors possess different functions and characteristics, but little is known about the relative validity or utility for promoting physical activity in the population. This article provides an overview of various consumer-based monitors and their potential utility for promoting physical activity in the population.