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Fitness-Tracker and smartwatches

Date: 7th of July 2020

Fitness trackers and smartwatches are wireless electronic devices that people usually wear on their wrist or arm. With the aid of sensors, fitness trackers record data relating to a person's bodily functions and fitness, such as their pulse, heart rate, calorie consumption, movements and their activity and sleeping patterns. Smartwatches have additional functionality similar to that found on smartphones. Both device categories are classed as wearables; in other words, wireless devices that people wear directly on their bodies for long periods while switched on.

Fitness trackers and smartwatches can use low-powered wireless technologies to communicate with other devices such as smartphones and wireless routers (Wi-Fi) and access the Internet. Certain devices can also access the Internet directly via a more powerful mobile phone connection.

Because of the way they are worn, fitness trackers and smartwatches result in radiation exposure on the wrist, arm or other parts of the body with which they come into contact. Some of this radiation may enter the body. To avoid any risk to health, this radiation must fall within the exposure limits that apply for the safety of telecommunication devices.

The Swiss Federal Office of Public Health has had the radiation of some of these devices measured. The following recommendations can be inferred from these measurements:

- The amount of radiation emitted by fitness trackers and smartwatches is low if they access other devices via low-powered wireless technologies (Bluetooth) or connect to the Internet via smartphones or wireless routers. If you use a fitness tracker or smartwatch to access the Internet via a smartphone, you can reduce your exposure to radiation by not carrying the smartphone directly against the surface of your body.
- The radiation emitted by fitness trackers and smartwatches that connect to the Internet directly via the mobile phone network are higher and may possibly exceed the exposure limits.
- You can reduce your exposure to radiation by connecting only during a limited time to the mobile phone network, or by accessing the Internet via Wi-Fi.
- If you have an electronic implant such as a pacemaker, keep the fitness tracker or smartwatch at least 15cm away from the implant as a precautionary measure to avoid the implant malfunctioning.

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Detailed information

1 Design and radiation properties of fitness trackers and smartwatches

Most fitness trackers and smartwatches use Bluetooth wireless technology. Depending on the model, they may communicate via other low-powered wireless technologies such as Wi-Fi or near field communication (NFC) with an accompanying smartphone or other compatible devices such as payment terminals or wireless routers; they may control such devices, or access the Internet via them. Some models can access the Internet directly via a 3G, 4G or 5G mobile phone connection. Table 1 shows a summary of the wireless technologies used and their principal properties:

Table 1 Wireless technologies used in fitness trackers and smartwatches

Technology	Application	Range	Frequency [MHz]	
NFC	Mobile payment	4 -10cm	13,56	Transmit / receive
Bluetooth Low Energy (BLE)	Connecting directly with other BLE devices	10m	2400-2480	Transmit / receive
Bluetooth version: 4.0 / 4.1 / 4.2 / 5.0 / 5.1	Connecting directly with other Bluetooth devices	Class 3: less than 10m Class 2: 10m	2400-2480	Transmit / receive
Wireless LAN (Wi-Fi): IEEE 802.11b IEEE 802.11g IEEE 802.11n IEEE 802.11ac	Connecting to Internet or other WLAN devices via a WLAN router	30m indoors 100m outdoors	2447	Transmit / receive
GSM 900	2G mobile phone	Dependent on the mobile phone provider's coverage	897,6	Transmit / receive
GSM 1800	2G mobile phone		1747,6	Transmit / receive
UMTS 900	3G mobile phone		897,6	Transmit / receive
UMTS 1950	3G mobile phone		1950	Transmit / receive
LTE	4G mobile phone		800; 900; 1800; 2100; 2600; 3400-3800	Transmit / receive
5G	5G mobile phone		700 1400 2600 3500-3800	Transmit / receive
GPS	Satellite navigation	Outdoors, occasionally indoors		Receive
GLONASS	Satellite navigation			Receive
Galileo	Satellite navigation			Receive

2 Radiation emitted by fitness trackers and smartwatches

2.1 Health effects of high-frequency radiation

There are no specific studies on the health effects of the high-frequency radiation emitted by fitness trackers and smartwatches. But there are a large number of studies that have examined the effects on humans of high-frequency radiation from other similar technologies. Scientific bodies have evaluated the findings of these studies on several occasions.

For example, in 2019 the Swiss “Working group on mobile telephony and radiation”, commissioned by the Department of the Environment, Transport, Energy and Communications (DETEC) summarised the findings of recent studies and also the evaluations of other bodies on high-frequency radiation from mobile communications. The working group restricted itself to studies and evaluations published since 2014 [1]. The working group classified the carcinogenic effect of high-frequency radiation as plausible only to a limited extent. However, it did consider certain physiological effects in humans to be plausible. For example, mobile phones held against the head can influence neural oscillations when people are awake and also asleep. Having said that, no risk to health can be inferred from these effects. However, the effects of high-frequency electromagnetic radiation on people’s wellbeing cannot be experimentally proven. While many studies involving cells and animals have found biological effects, the findings of these studies are not uniform and do not show a consistent pattern between radiation and effect, for instance. The working group’s report also highlighted considerable differences between the evaluations of individual bodies. Overall, no body concluded that the high-frequency radiation emitted by mobile communications represents a causal risk to human health.

This conclusion had already been reached by the International Agency for Research on Cancer (IARC) prior to the DETEC report. In 2011, it comprehensively evaluated the available data on high-frequency radiation. Based on studies into the radiation emitted by mobile phones, the IARC classified high-frequency radiation as “possibly carcinogenic” (Group 2B [2]. This classification means that epidemiological studies and animal studies have shown signs of carcinogenic effects. These effects may possibly lead to an increased risk of brain tumours for people who spend a lot of time telephoning with the phone against their ear. But the 2B classification also means that these studies have shortcomings concerning both their methodology and their assessment of how much radiation these people are exposed to. According to the IARC, the evidence is therefore only of limited significance for a conclusive evaluation of the risk that high-frequency radiation poses to human health. The 2011 IARC evaluation was and still is considered internationally to be an authoritative evaluation of the health effects of high-frequency radiation.

Interference with implants

FOPH is not aware of any published studies on interference with implants by fitness trackers and smartwatches. Implant manufacturers recommend maintaining a 15cm separation between fitness trackers and the implanted device as a precaution to avoid the implant malfunctioning [3].

2.2 Exposure limits

High-frequency radiation that heats up a person's tissue to such an extent that thermal damage occurs represents a demonstrable risk to health.
To prevent high-frequency radiation from causing such acute health risks, the International Commission on Non-Ionizing Radiation Protection recommended applicable exposure limits in 1998 (ICNIRP 1998) [4]. These exposure limits restrict the amount of radiation absorbed by the body so that it does not heat the body up excessively and does not lead to acute health risks. Appliances may therefore emit radiation such that, when used for their usual and intended purpose, it falls within the exposure limits. These exposure limits include a safety factor of 50 for the general population. The basic measure for exposure limits is the radiation energy absorbed by the body per time interval and body volume. The unit of measure is the power absorbed per mass of body tissue. It is referred to as the specific absorption rate (SAR value) and is specified in watts per kilogramme (W/kg). The exposure limits vary depending on the part of the body being irradiated, and relate to different masses of tissue. The limit for local exposure of the body must be adhered to in each mass of tissue weighing 10 grams. For the head and trunk, the limit is 2W/kg or a maximum of 0.02W/10g. For limbs, it is 4W/kg or a maximum of 0.04W/10g. If the entire body is homogeneously irradiated, the exposure limit is 0.08W/kg. Unlike the exposure limit for local irradiation, the limit for homogenous radiation must be adhered to in each mass of tissue weighing 1kg.

According to the ICNIRP, the long-term effects of high-frequency radiation and also the effects of weak high-frequency radiation cannot be conclusively assessed due to the current state of scientific knowledge. The ICNIRP has therefore based its exposure limits solely on established findings relating to acute health risks due to strong high-frequency radiation.

2.3 High- frequency radiation emitted by fitness trackers and smartwatches

The Swiss Federal Office of Public Health had the SAR values of one fitness tracker and two smartwatches measured at the ITIS Foundation in Zurich [5]. This study does not constitute a market overview. However, it does make it possible to estimate the order of magnitude of radiation exposure by these devices when they use different wireless technologies.

Measurement technology

The high-frequency radiation emitted by fitness trackers and smartwatches may affect the wrist or lower arm in particular. Depending on the position of the arm, other parts of the body may also be exposed, such as the trunk or brain. To test whether the radiation from these devices falls within the exposure limits in these individual situations, different measurement processes are necessary. These measurement processes are described in international, European and Swiss standards (see also section 3 Legal situation).

During the measurement processes, the fitness trackers and smartwatches are operated in the modes in which they emit the most radiation (worst-case scenario). Their SAR values are established separately for each of their frequency bands using a "phantom", i.e. a model of the irradiated body part. The results depend greatly on the distance between the irradiating device and the phantom at the time of measurement. This distance is defined in the standard that describes the measurement process for devices that

are hand-held or worn on the body. According to the standard, this distance must be the same as the usage distance specified in the device's operating instructions. If the manufacturer does not specify this usage distance, all the surfaces of the device must be tested directly against the phantom with no clearance. Since no usage distances are provided in the operating instructions for the devices, they are attached directly to the phantom with no clearance when the readings are taken.

Phantoms may either replicate the geometry of a body part or have a simplified shape. To measure the fitness trackers and smartwatches, two different phantoms are used for two different usage cases for the devices.

The first case involves the radiation in the head of a person who has bent their arm so that the front of a fitness tracker or smartwatch is touching their head. In this case, a simplified "flat phantom" is used that is shaped like a head and is filled with liquid (Figure 1). So that the phantom corresponds to the body tissue of a head as closely as possible, the electrical properties of the liquid have to be as similar as possible to the electrical properties of the tissue in a human head. A large number of very small antennae are fixed inside the phantom to measure the radiation that penetrates it. The individual readings make it possible to calculate the distribution of the radiation within the phantom. During the various measurements, the fitness tracker or smartwatch is placed directly on the phantom in defined positions, so that the following parts of the device are in contact with the phantom: a) watch dial, b) edge of the watch dial, c) right-hand side of the watch strap, d) left-hand side of the watch strap, e) crown, f) measurement points at the side of the devices, g) loudspeaker.

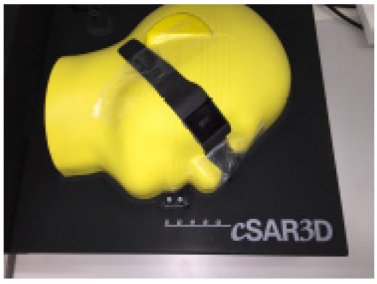

Figure 1 Flat phantom of a head with smartwatch

The second case involves the radiation in the arm of a person wearing a fitness tracker or smartwatch on their wrist. In this case, the phantom used is shaped like an arm and filled with liquid (Figure 2). So that the measurements generate realistic results, the phantom has to mimic the bodily tissue of an arm as closely as possible. This is achieved by matching the electrical properties of the liquid as closely as possible to the electrical properties of the tissue of an arm. During the measurements, the reverse side of the fitness tracker or smartwatch is attached to the phantom with no clearance. At the top of the apparatus, a dosimetric measurement system with a single antenna measures the radiation in the liquid within the phantom (Figure 2). A robotic arm positions the antenna at various points within the phantom to establish the distribution of the radiation and find the point that is most strongly irradiated.

Figure 2 Dosimetric measurement system; phantom of an arm with smartwatch

Results

The measurements in the worst-case situation showed that the strongest radiation occurred at the edge of the watch dial and on the reverse side of the device (the arm side). Table 1 shows these results for the individual devices as absolute values and as a percentage of the relevant exposure limit.

Table 2 SAR values for one fitness tracker and two smartwatches

Wireless standard	**SAR: measurement display side [W/kg]** [1]	**SAR as a percentage of exposure limit, display side** (exposure limit for head and trunk: 2W/kg)	**SAR. measurement arm side [W/kg]** [2]	**SAR as a percentage of exposure limit, arm side** (exposure limit for limbs: 4W/kg)
Fitness tracker				
Bluetooth	Not measurable	0	Not measurable	0
Smartwatch 1				
Bluetooth and WLAN IEEE 802.11n together	Not measurable	0	0.032	<1%
Smartwatch 2				
Bluetooth	0.03	<2%	Not measurable	0
WLAN IEEE 802.11n	0.055	<3%	0.038	<1%
GSM 900MHz	0.938	47%	1.47	37%
GSM 1800 MHz	0.931	47%	1.58	40%
UMTS 900MHz	0.959	48%	1.67	42%
UMTS 1950MHz	2.15	108%	3.21	80%

2.4 Health evaluation

The results show that the SAR values of fitness trackers and smartwatches that communicate via a Bluetooth or Wi-Fi connection are far below the exposure limits. No risk to health has been proven at such low levels of radiation exposure.

When fitness trackers and smartwatches communicate directly with the Internet via a mobile phone connection, this results in higher SAR values within the same range as the SAR values of mobile phones, and which may under some circumstances exceed the exposure limits. Whether such higher levels of

[1] Measurement in the flat phantom of the head
[2] Measurement in the phantom of the arm

radiation pose a health hazard cannot be conclusively assessed due to the limited number of studies. Moreover, due to the different types of use and differing exposure of bodily tissue, it is not possible to ascertain whether the IARC classification for mobile phones as “possibly carcinogenic” also applies to fitness trackers and smartwatches that use mobile phone technology.

As a precautionary measure it is therefore recommended that mobile phone connections should only be used for a limited period of time and, where possible, that low-radiation Bluetooth or Wi-Fi connections should be used instead.

3 Legal situation

3.1 Basis in law

According to Swiss law, fitness trackers and smartwatches are classed as radio equipment and are subject to the Swiss Ordinance on Telecommunications Installations (TIO – SR 784.101.2) [6]. Amongst other things, this ordinance requires that radio equipment be manufactured in such a way that the protection of health, the safety of people, pets and farm animals and the protection of property are ensured. Moreover, the objectives contained in the Ordinance on Low-Voltage Electrical Equipment (KVEO – SR 734.26) [7] regarding safety requirements must be met with no voltage limit. For the specific details of the safety objectives, the LVEO references Annex I of the European Union’s Low Voltage Directive [8]. This includes a safety objective specifying that low-voltage electrical equipment may not generate any radiation that could be hazardous.

To prove that their products conform with the safety objectives, manufacturers are obliged to carry out a conformity assessment, thereby ensuring that the fundamental TIO requirements have been met. However, the legal foundations do not oblige manufacturers to declare the SAR values of their devices to the public on their packaging, in their operating instructions or in any other way.

3.2 Standards

So that the safety objectives for radio equipment specified in legal foundations can be verified, the appropriate agencies in the Department of the Environment, Transport, Energy and Communications (DETEC) designate technical standards. These standards are prepared by the *European Committee for Standardization (CEN)*, the *European Committee for Electrotechnical Standardization (CENELEC)* or the *European Telecommunications Standards Institute (ETSI)* under mandate.

Standards that concern human safety in connection with high-frequency radiation from radio equipment describe the procedure for measuring radiation and define the criteria according to which radio equipment is deemed to be safe. Two standards are authoritative for radiation emitted by fitness trackers and smartwatches:

- The Swiss and EU standard SN EN 62209-2:2010 [9] concerns the measurement process by which the SAR values of wireless communication devices worn on the body can be determined. This standard makes reference to the detailed standard IEC 62209-2:2005 produced by the

International Electrotechnical Commission (IEC) [10]. A new version of the 62209-2 standard is likely to be published in 2020 and will make reference to IEC 62209-2 dated 2019.

- The Swiss and EU standard SN EN 50566:2017 [11] describes the criteria that must be met in order for a communications device to fulfil the technical requirements of the relevant Swiss and EU legal provisions and be classed as safe. It makes reference to both the SN EN 62209-2:2010 standard [9] and the exposure limits in the "Council Recommendation of 12 July 1999 on the limitation of the exposure of the general public to electromagnetic fields (0 Hz - 300 GHz)" [12]. The exposure limits in the EU Recommendation are based on the ICNIRP recommendations [4].

Manufacturers are at liberty to apply these standards. If their products comply with the safety objectives within the scope of the standards, they can presume that their products comply with these safety objectives. However, manufacturers are free to demonstrate the conformity of their products in a different way, which would however be more time-consuming and complicated for them.

4 Bibliography

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[8] 2014/35/EU RICHTLINIE 2014/35/EU DES EUROPÄISCHEN PARLAMENTS UND DES RATES vom 26. Februar 2014 zur Harmonisierung der Rechtsvorschriften der Mitgliedstaaten über die Bereitstellung elektrischer Betriebsmittel zur Verwendung innerhalb bestimmter Spannungsgrenzen auf dem Markt

[9] SN EN 62209-2:2010 – Sicherheit von Personen in hochfrequenten Feldern von handgehaltenen und am Körper getragenen schnurlosen Kommunikationsgeräten – Körpermodelle, Messgeräte und Verfahren – Teil 2: Verfahren zur Bestimmung der spezifischen Absorptionsrate (SAR) von schnurlosen Kommunikationsgeräten, die in enger Nachbarschaft zum menschlichen Körper verwendet werden (Frequenzbereich von 30 MHz bis 6 GHz)

[10] IEC 62209-1:2005, Human exposure to radio-frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures – Part 1: Procedure

to determine the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)

[11] SN EN 50566:2017: Produktnorm zum Nachweis der Übereinstimmung von schnurlosen Kommunikationsgeräten mit den Basisgrenzwerten und Expositionsgrenzwerten für die Exposition von Personen gegenüber elektromagnetischen Feldern im Frequenzbereich von 30 MHz bis 6 GHz: In enger Nachbarschaft zum menschlichen Körper handgehaltene und am Körper getragene Geräte

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