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Exploring public attitude toward biofeedback technologies: Knowledge, preferences and personality tendencies

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Abstract

Background: Biofeedback is increasingly used in the clinical area and in daily health monitoring through wearable devices (e.g. smart watches). Nevertheless, it remains rather unknown. This study aimed to assess, in a sample of Italian citizens, the level of knowledge, attitudes, perceived efficacy and personality tendencies which could affect the uptake of biofeedback technologies.

Design and Methods: Participants were recruited by advertising the survey on the social networks, from March to May 2019. 160 subjects filled in an *ad hoc* online questionnaire assessing socio-demographic variables, clinical status, physical activity, knowledge and attitude towards biofeedback, psychological tendencies toward health.

Results: Data showed a good level of interest in biofeedback training in spite of poor knowledge about such technologies. Sport and chronic diseases were not correlated to a greater use of biofeedback. People informed about biofeedback technologies were more interested in undergoing biofeedback training and had higher scores in the Health Locus of Control. Finally, people who showed a positive perception of their own health (Health Esteem) did not rely on these technologies.

Discussion: Despite the huge spread of biofeedback technologies, our results disconfirmed the expectation that people having an active lifestyle or a disease were more familiar with biofeedback systems. The attitude toward such technologies seems to depend on individual tendencies.

Conclusions: This study suggests the importance to improve general public literacy on biofeedback technologies, tailor tools on their needs and characteristics, empower people's sense of internal health control for promoting a valid use and a proper knowledge of biofeedback.

Introduction

In the last fifty years, the medicine has been betting on inno-

vative treatments and new technologies to tackle a great number of diseases. Biofeedback is one of them: it is a technique of psychophysiological measuring and intervention, able to report physiological parameters in real-time (such as heart rate and respiratory variability, skin conductance, body surface temperature, electroencephalogram, pressure sensors, muscle tension, and the range of joint movements) on a user-friendly monitor.¹⁻³ It implies the use of advice and of two different strategies to relay physiological outputs to the subjects, depending on how accurately the internal biological process is reproduced: i) direct feedback on a monitor reporting the real value of the measure, as in the case of heart rate; ii) transformed feedback, which reproduces a representative signal (auditory, visual or tactile) of the parameter, as in the case of electromyography (EMG). Biofeedback can increase people's awareness of the effect that their actions, emotions, and thoughts could have on their body so that they can play an active role in restoring their health status and learn self-regulation strategies.^{1,4}

In the beginning, it was used to treat different diseases such as Raynaud's disease, spasmodic torticollis, asthma, arterial hypertension, hemiplegia, hemiparesis and paraparesis.^{3,5} Nowadays, the application of biofeedback is extended to psychophysical rehabilitation, sports performance/training, and wellness. The largest and promising application field of biofeedback is in the area of physical rehabilitation,^{3,8,9} where it may help patients to improve accuracy, engagement in the exercises and allow healthcare professionals to control the implementation of the rehabilitation programs. In this field, biofeedback techniques could be categorized into at least 4 different typologies: neuromuscular biofeedback (that is used in musculoskeletal, neurological and neuromotor rehabilitation); cardiovascular biofeedback (that is used in the treatment of hypertension, heart failure, asthma, and fibromyalgia); respiratory biofeedback (for patients with respiratory diseases, such as cystic fibrosis, and for promoting relaxation in patients with anxiety or hypertension); biomechanical biofeedback (aimed at motor learning in sports and rehabilitation).^{3,10,11}

Psychiatric and psychological disorders can take advantage of biofeedback technologies as well.⁹ In particular, there is evidence of their efficacy in the treatment of stress, anxiety, depression and

Significance for public health

Despite the huge application of biofeedback technologies in different areas, the technological progress and availability of biofeedback tools does not go hand-in-hand with the general public's knowledge and attitude for such tools. This contribution focuses on the importance to improve general public literacy on these technologies, for disseminating correct messages on their usefulness for well-being, and highlight the importance to tailor technologies on people's real needs.

cognitive disorders (attention-deficit/hyperactivity disorder, learning disabilities), substance abuse and psychiatric disorders (e.g., schizophrenia, autism, obsessive-compulsive disorders, *etc.*).¹² People can learn to modify their maladaptive physiological response to specific stimuli, strictly associated with the disease.¹² EEG biofeedback (or neurofeedback) is proven to be efficient in cancer-related comorbidities treatment. Two reviews report that cancer patients and cancer survivors often experience fatigue, cognitive impairment, pain, anxiety, and depression,^{13,14} and EEG biofeedback is helpful in alleviating some of these symptoms.^{14,15}

Biofeedback is used by healthy subjects, athletes and coaches to improve sports performance.¹⁶ Heart rate variability (HRV), in particular, is a safe, rapid and accessible method to improve the autonomic regulation of heart through the practice of slow breathing, lowering the level of anxiety and stress, during and before a performance.^{1,17,18}

Finally, with the massive distribution of smart phones, tablets and smart watches the public is getting used to wear biofeedback devices and to monitor their physiological activity (e.g., through activity trackers or sleep trackers). This is a great opportunity to move the field of biofeedback from its unknown state to being on the forefront of healthcare for the learning of self-regulation skills and internal health care.

Starting from these premises, we might suppose that the new generations particularly interested in tech and device are now becoming aware of biofeedback usefulness. In particular, we might expect that people who are physically active, or athletes, or people who have to manage chronic diseases have greater knowledge or attitude toward the use of these technologies, along with specific personality aspects that affect health-related behaviors and the interest toward mind-body technologies. This study aimed to assess, in a sample of Italian citizens, the level of knowledge of psychophysiology and biofeedback, the interest toward biofeedback training, perception about its efficacy and personality tendencies that could be closely correlated with the attitude in the use of biofeedback tools. Such evidences contribute to estimate how much it is necessary to get lay people closer to this technological area, along with bringing the public to be an active participant in one's own health, rather than passive recipient of medical services and medication.

Design and Methods

Participants and procedure

The sample of participants was recruited through social networks, by advertising the survey and its link, from March 2019 to May 2019. Data were collected using Survey Monkey, an online open-source application that enables users to develop and publish online surveys and register responses (www.surveymonkey.com). The final sample was composed of 160 respondents. They were basically young adults (ages 18-30 years), adults and middle-aged adults (ages 30-65 years; only a couple of participants had an age over 65).¹⁹ Previous studies already showed that this cohort of people has more attitude towards new health technologies, is more interested in scientific progress and more confident with the use of Internet services and platforms. An information sheet has been provided to explain the scope of the study and the procedure to complete the survey, and the informed consent was signed by all participants. It has been estimated that the time required for filling in the questionnaire was 15 min. Participation in the study was voluntary and data collected were anonymized. The research protocol was approved by the Institutional Review Board of the University of Milan and the Ethical committee of the European Institute of Oncology IRCCS (Protocol number: IEO0609).

Measures

The enrolled participants completed a structured and self-administered ad hoc questionnaire that assessed socio-demographic aspects (gender, age, marital status, educational level, and current employment), clinical variables (currently suffering or having suffered in the past from specific diseases, psychological disorders, *etc.*), level of biofeedback knowledge and attitudes towards psychophysiology/biofeedback. Furthermore, participants were provided with a brief definition and description of the biofeedback followed by a set of questions that evaluated the level of perceived knowledge about psychophysiology, biofeedback, the use of biofeedback for health, and the attitude to undergo training with biofeedback application. Questions concerning this last section have been reported in Table 1.

Table 1. List of topics and relative items of the survey.

Questions about the knowledge of psychophysiology and biofeedback	
Question	Answer
"Which is your knowledge about psychophysiology?"	Rated on a scale from 0 no knowledge to 10 extreme knowledge
"Have you ever heard about biofeedback?"	Yes or no
"Have you ever heard about the use of biofeedback in the clinical setting?"	Yes or no
Questions about the possible sources of information	
Question	Answer
"Where did you gather information?"	Multiple answers: e.g from the doctor, from the internet, from school/university, etc.
Questions about the motivations for accepting and/or refusing biofeedback techniques and their applications for health	
Question	Answer
"Have you ever done biofeedback training?"	Yes or no
"How much would you be willing to undergo biofeedback training?"	Rated on a scale from 0 no interested to 10 extremely interested
"For which reason would you consider undergoing a biofeedback treatment?"	Multiple answers: e.g In this way I can monitor my health, It could satisfy my curiosity, It might be funny, etc.
"For which reasons would you not consider undergoing a biofeedback treatment?"	Mmultiple answers: e.g The results are unreliable, I'm not interested to know my physiological status, I would be worried about sensors on my body, etc.
"How much do you think biofeedback training could be an efficient technique?"	Rated on a scale from 0 not at all efficient to 10 extremely efficient

Two parameters to assess the physical status were included, BMI and the level of physical activity, measured through the International Physical Activity Questionnaire – short form (IPAQ) in order to measure if physical habits could influence the knowledge and interest in the application of biofeedback. The IPAQ short form includes three specific types of activity: low physical activity (such as walking), moderate physical activity (such as at least 10 min of swimming or ride a bike), vigorous physical activity (such as at least 10 min of playing football or running). For each type of activity, participants had to specify how many times physical activity they performed, expressed in min per day/week. A total score for each participant was calculated following the Guidelines for Data Processing and the analysis of the IPAQ scores,²⁰ are reported in Table 2.

Participants have been then distributed into 3 classes of physical activity levels (high, moderate, low) based on cut off established in the IPAQ Guidelines for Data Processing.

Finally, the *Health Orientation Scale (HOS) Italian version* has been submitted to the participants. The HOS is a scale developed by Snell and colleagues²¹ assessing personality tendencies which can be associated with the implementation of health behaviors and to the promotion of personal well-being. An Italian adaptation is now available by Masiero *et al.*²² The Italian version of HOS is a self-report tool composed of 36-items, divided into seven subscales:

1) *Motivation for health promotion and prevention (MHPP)* (9 items), which describes people that are strongly motivated to defend their well-being, to activate strategies which avoid risk behaviours that might compromise their health status and to adopt preventive behaviors ($\alpha = 0.882$) (score ranging from 0 to 36); 2) *Health esteem (HES)* (7 items), which represents the tendency to have positive thinking and confidence in handling health status, to be optimistic about the future and to perceive themselves in good physical shape ($\alpha = 0.838$) (score ranging from 0 to 32); 3) *Health Image Concern (HIC)* (5 items), which describes people who usually behave based on the impression they want to give about their health and are more vulnerable to sudden behavioural changes ($\alpha = 0.832$) (score ranging from 0 to 20); 4) *Personal health consciousness (PHC)* (4 items), defined as the dispositional tendency to spend time thinking about one's physical health and fitness ($\alpha = 0.822$) (score ranging from 0 to 16); 5) *Health Locus of Control (HLC)* (5 items), which describes people who overall believe that their well-being is under their responsibility, under their direct control ($\alpha = 0.770$) (score ranging from 0 to 20); 6) *Health anxiety (HA)* (4 items), which identifies people whose health perception is modulated by mood factors, such as worry and anxiety ($\alpha = 0.797$) (score ranging from 0 to 16); 7) *Health Expectations (HEX)* (2 items), which describes people with negative expectation for their future health status ($\alpha = 0.716$) (score ranging from 0 to 8).

Participants were asked to indicate how much each statement reflects their profile, on a 5-point Likert scale (0 = not at all characteristic of me, 1 = slightly characteristic of me, 2 = somewhat characteristic of me, 3 = moderately characteristic of me, and 4 = very characteristic of me). Total scoring for each subscale was the sum of the points assigned to the corresponding items.

See supplementary material for a detailed description of the survey.

Statistical analysis

Descriptive statistics were calculated on raw data to report the socio-demographic characteristics, the psychological and psychophysical health status of the participant enrolled and to describe the main sources of information and level of knowledge about

Biofeedback. Descriptive data (frequencies and/or mean and standard deviation) were even calculated to describe the participant distribution about perceived knowledge, perceived utility, and attitudes toward biofeedback training. Contingency tables and Chi-Square tests were performed to make comparisons among groups distinguished on the basis of socio-demographic aspects (gender, level of education), clinical variables (psychological and physical suffering) or physical activity categories (high, moderate, low physical activity), with the knowledge of psychophysiology, biofeedback and its application in healthcare. Expected values and residuals in every box were calculated, in order to verify if a specific group gave a significantly higher or lower rate of response (observed values) to certain items, compared to the percentage expected and calculated on the number of subjects recruited. The Pearson product-moment coefficient had been used to measure the correlation between continuous variables (2-tailed, $p < 0.05$), such as attitude toward the biofeedback training correlation with participants' age or level of physical activity. One-way ANOVA and T-test were performed to analyze possible differences among groups, based on socio-demographic variables or biofeedback knowledge, in the level of attitude/interest toward biofeedback training and the perceived efficacy. Finally, Pearson product-moment coefficients were calculated to investigate correlations between personality profiles and knowledge and attitudes toward biofeedback.

Analyses were performed with the SPSS package (version 25.0, IBM, USA, 2014).

Results

Table 3 describes the socio-demographic characteristics of the participants. 68.6% of the total subjects enrolled (160) were females (109). Their mean age was 35 (SD = 10) (minimum = 21 and maximum = 72) and among them, 41.3% was married or cohabiting, 46.2% had a bachelor's degree, whereas 19.2 % had a higher instruction that ranged from master's degree to Ph.D. and/or specialization.

According to the international classification, the overall sample had a normal BMI ($M = 22.51$ $SD = 3.38$). 41.3% declared to have current psychological suffering (anxiety, depression or sleep disorders) or had suffered in the past, whereas 18.9% were currently suffering from specific physical diseases but only 4% of participants undergo a regular medical check-up. More than half of the sample never or rarely undergo medical checkup (60%).

The overall knowledge of psychophysiology among the participants was very low ($M = 2.95$, $DS = 2.75$): only 29.4% of subjects declared to know the biofeedback and 21.5% were aware of the biofeedback application in healthcare.

No differences emerged about the level of knowledge based on gender and age, but this result should be considered with caution,

Table 2. Processing and the analysis of the IPAQ.

Types of physical activity (min/week)	Processing and the analysis of results
Low activity	3.3 * min * days
Moderate activity	4.0 * min * days
Vigorous activity	8.0 * min * days
Total activity	Sum of Low + Moderate + Vigorous min/week scores

since the sample is not well balanced for these socio-demographic variables. There was a significant difference between groups regarding the educational level and knowledge of psychophysiology ($F_3 = 6.64, p < 0.01$). Participants with advanced educational level (post-academic education, e.g. Master, specialization, etc.) had a higher level of knowledge of psychophysiology ($M = 4.97, DS = 2.53$) compared to bachelor's degree level ($M = 2.36, DV = 2.67$) or high school level ($M = 2.67, DS = 2.58$). The same group had a significantly higher probability to know the biofeedback ($X^2(3) = 20.56, p < 0.01$) compared to the other groups, and its application in the healthcare ($X^2(3) = 22.86, p < 0.01$) compared to the people with a degree level of education. Only two participants reported previous experience with biofeedback training, and both had a post-academic education.

Data about the main sources of information concerning biofeedback and its application in healthcare are reported in Figure 1. As represented in Figure 1, the main sources of information recognized by participants were the School/University (42.6% biofeedback, 10.6% biofeedback in healthcare), or professional experience (27.7% biofeedback, 8.1% biofeedback in healthcare). The Internet was a good source of information for biofeedback knowledge too (27.7%).

We verified if the psychological and physical status (having psychological suffering or disease), and physical activity scoring could reflect a higher knowledge in biofeedback and its application. Results showed no difference or correlations based on these variables.

Attitudes towards biofeedback technologies and training

There was a good attitude toward the biofeedback training (question "How much would you be willing to undergo a biofeedback training?" ranged on a scale from 0 to 10, the mean score was $M = 6.01; DS = 2.82$), with no difference based on gender, psychological (sleep disorders, anxiety, depression) or physical status (e.g., participants mentioned osteoarthritis, thyroiditis, hypertension, hypothyroidism, celiac disease, migraine, diabetes) and no correlation with age and with physical activity. Participants tended to believe that biofeedback training could have moderate efficacy ($M = 5.56; SD = 2.47$) and a significant correlation was found between the interest in undergoing the biofeedback training and the perceived efficacy of the same ($r = 0.768; p < 0.01$). No differences emerged between people who had knowledge and people who ignored this kind of technique in the level of attitude/interest toward biofeedback training and the perceived efficacy (both groups showed a good attitude and perceived efficacy).

The foremost reasons to get biofeedback training, selected by

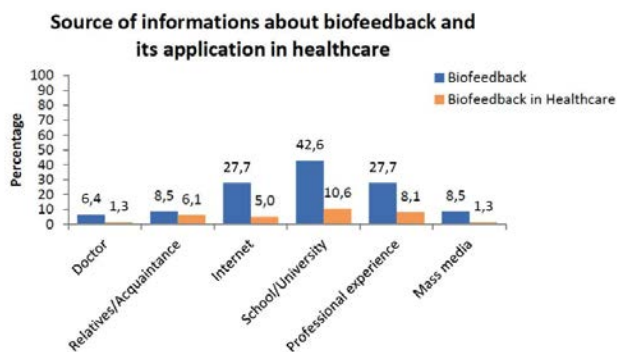


Figure 1. Sources of information concerning biofeedback selected by participants.

the participants, were "I think it would be helpful to learn behaviors able to improve my health status (breathing rate, relaxing, etc.) without the application of the device" (46.9% participants), "I think it could be useful to know my health status (42.5% participants), and "Curiosity" (34.4% participants), as described in Figure 2.

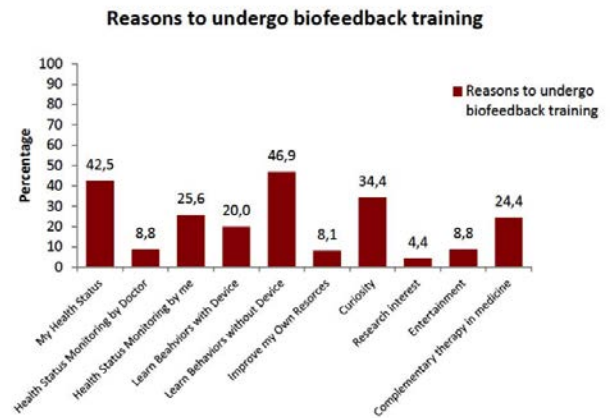


Figure 2. Reasons for undergoing biofeedback training selected by participants.

Table 3. Socio-demographic variables.

Socio-demographic variable	n (%)
Sex	
Male	50 (31.4%)
Female	109 (68.6%)
Marital status	
Single	41 (25.9%)
Engaged in a relationship	41 (25.9%)
Married/common-law partner	66 (41.8%)
Separated/Divorced	9 (5.7%)
Widowed	1 (0.6%)
Educational level	
No education	0 (0%)
Primary level (Elementary school)	4 (2.6%)
High school	50 (32.1%)
Degree	72 (46.2%)
Postgraduate	30 (19.2%)
Current employment	
School student	14 (8.8%)
University student	8 (5%)
Not working but looking for a job	3 (1.9%)
Not working and not looking for a job	0 (0%)
Housewife	9 (5.7%)
Laborer	17 (10.7%)
Fixed-term work	54 (34%)
Office work	36 (22.6%)
Freelance professional	2 (1.3%)
Retired	1 (0.6%)
Unable to work	2 (1.3%)
Permanent work	13 (8.2%)
Country origins	
North	72 (45.3%)
Centre	61 (38.4%)
South	26 (16.4%)
Mean (SD)	
BMI	22.51 (3.383)
Age	35.51 (10.138)

The most recurrent motivation that guided the reject of biofeedback training was: “The results might cause worry about my health status” (15%) and “I am worried about the application of the sensors”. The overall answers are reported in Figure 3.

Personality tendencies correlated with the knowledge and attitudes toward biofeedback

Results showed that subjects who claimed to know the biofeedback had higher scores in Health Locus of Control subscale ($t(158) = 2.210$; $p=0.029$) compared to people who did not know. Furthermore, the Health Locus of Control had positive correlation with interest in undergoing biofeedback training ($r = 0.240$; $p<0.001$) and perceived efficacy of the same ($r = 0.218$; $p<0.001$). There was no significant difference in health personality tendencies between people who knew about the application of biofeedback in healthcare and people who did not know.

The Health Esteem negatively correlated with interest in biofeedback training ($r = -0.258$; $p<0.001$) and with perceived efficacy of these technique ($r = -0.246$; $p<0.001$).

Discussion

Biofeedback has been increasingly used over the last decades both in clinical and sports areas. It gives the opportunity to enhance people engagement in the management of their clinical conditions, to reduce the need for ongoing contact with healthcare professionals, to monitor health status or implement a rehabilitation program, and to promote the well-being.²³ Another frequent application is related to sports and performance enhancement. Athletes usually focus the attention on their physical achievements, and biofeedback technologies can easily provide them this information while practicing.¹ Despite these advantages in using biofeedback technologies, usually people are not informed about their applications or do not understand their actual functioning or utility. For this reason, the aim of this contribution was to explore and discuss in a sample of Italian citizens the level of knowledge, beliefs about biofeedback and the sources of information.

Reasons not to undergo biofeedback training

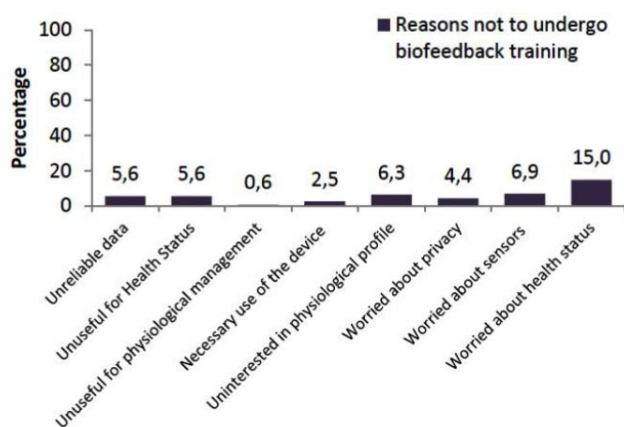


Figure 3. Reasons for rejecting biofeedback training selected by participants.

Results showed that the overall knowledge about psychophysiology and biofeedback was low. Just a poor fraction of participants (around 1/4) heard about biofeedback before this survey, only 21% was informed about the application of these technologies in healthcare, and just 2 participants had previous experience with biofeedback training. Age and gender were not significant factors influencing such aspects. The main source of information about biofeedback technologies and training was the university (the academic background). It seems that the psychophysiology and the biofeedback technologies application are scientific topics studied in advanced formation or in specialized fields in Italy. The second source of information reported by participants was the web (internet). This result was not surprising since it is well-known that the current tendency for healthy people and/or patients is to look for health-related information online.²⁴ Technological innovations tools and apps are daily used to improve people’s lives and performances, including mobile applications, smartwatches, small portable devices with embedded sensors, to record and provide users with feedback on many different physical variables.²⁵ Nevertheless, people might use them without really knowing them, or without having any idea of the functioning at the basis of such technologies. People find really difficult to associate modern devices and mobile apps to the world of psychophysiology and biofeedback technologies. This would mean that stakeholders should inform the public, interview consumers to identify their needs and involve them to prove the effectiveness of biofeedback products.^{26,27}

Overall, we found a good attitude toward the biofeedback training in our population (mean score of 6 on a scale from 0 to 10) and a moderate perception of its efficacy (mean score of 5 on a scale from 0 to 10). People who declared to have knowledge of biofeedback did not show a higher interest or perception of its efficacy compared to people with no literacy on that. Moreover, results described no differences in knowledge and attitude toward biofeedback among people who practiced high, medium or low physical activity, or based on age and gender, or among people with chronic physical condition (e.g., osteoarthritis, thyroiditis, hypertension, hypothyroidism, celiac disease, migraine, diabetes) and psychological suffering (such as sleep disorders, anxiety, depression). Thus, the idea that people who practice an active lifestyle, or people with health problems were more familiar with biofeedback systems was disconfirmed. This result again stresses the importance to inform and involve the public in scientific and technological progress, and make them aware of the opportunities that new technologies can offer. Our population has been asked about the reasons that could induce them to undergo biofeedback training or to reject it. Around half of participants recognized biofeedback as a helpful method to gather more information about their health status (and able to “coach” positive behaviors for control health status. Around 35%, was motivated by curiosity toward these technologies. The most of participants thought that it would be helpful to learn health-related behaviors and that it could be useful even without the permanent application of the device. Among the main reasons leading people to reject a biofeedback training, participants mentioned “The results might cause worry about my health status” or “[I am..] worried about the application of the sensors”. These results might be even correlated with the habits reported by participants about medical checkup: only 4% is used to undergo routine medical check-ups (60% never or rarely ask for a medical checkup). Anxiety, fear or worry are significant factors that could affect screening behaviors.²⁸⁻³⁰ Evidence in literature report that many people tend to avoid medical checkup and health-related examinations because of mistrust in physicians or health care organizations, because of high costs, no health insurance and

time constraints.^{31,32} Moreover, people perceive high discomfort with examinations dislike medical treatments or have preferences for self-care or alternative care. Other reasons are more connected with personality and psychological factors, such a low self-efficacy, fatalistic attitude, fear of having a serious illness, and thoughts of dying.³³ For this reason, psychological and personality variables merit more attention in studying the uptake and adoption of new health technologies for disease prevention and treatment.³⁴⁻³⁶

We investigated if and which personality attitudes toward health could influence biofeedback knowledge and interest in undergoing genetic testing. Interestingly our results showed that people who were informed about biofeedback had higher scores in Health Locus of Control compared to people who ignored these technologies. Moreover, people with higher scores in HLC, and thus who believed that their health status was determined by their own personal control, were more interested in undergoing biofeedback training and thought that it could be a useful tool. Previous studies already showed that the Health Locus of Control may influence the attitude and the individual ability to use biofeedback training efficiently.³⁷ HLC has been also associated with better health-related habits such as following a healthy diet³⁸ or having a greater mindset/trust/belief in the ability to control the risk of incurring in a disease.³⁹ Subjects with this personality tendency recognize the potential of a biofeedback device to increase the monitoring of their well-being.

Finally, another interesting result was the negative correlation we found between a higher Health Esteem (positive perception of one's own health) and the perceived efficacy of the biofeedback technology. It seems that people that consider their body as being in excellent and robust health do not rely on these technologies; this lack of interest might be a cause or an effect of less perceived efficacy. People might think that a biofeedback tool is needed only in case of a clinical condition, or in order to provide better care. To face these wrong beliefs, promoters of biofeedback applications should advertise that it has a great potential for health promotion, mental and physical wellness in general, in addition to the complementary and alternative therapy in medicine.²³ The health value is a strong factor that encourages participation in health-protective behaviors⁴⁰ and should be promoted even in biofeedback area.

Several limits of this study must be acknowledged. First of all, the survey targets a small part of the Italian population, specifically those with Internet access and ability to participate using the Survey Monkey platform. Other limits of this study are the average low age of the participants and the small sample size, which do not allow for generalization of the results. The investigated sample might not be fully representative of the Italian population, but provides a preliminary snapshot of the current situation. Our methods are correlational and cannot be used to infer causal relationships.

Conclusion

Biofeedback technologies and treatments are helpful for different medical conditions, well-being and physical performances. Despite people could gain benefits and advantages from these devices, our research shows that laypeople in Italy might have poor awareness about biofeedback technologies applications and utility. The level of curiosity and interest in biofeedback training is good, as well as the recognition of its function in learning strategies for exert control over physiological parameters and monitoring one's own health status. On the other hand, there is a great fear that these technologies could generate anxiety or concerns toward disease signals, feeding stereotypes. For this reason, we need to promote initiatives for improving general public literacy on these matters,

instead of leaving the availability of information limited to sectorial or academic levels. It is important to pass a correct message on the usefulness of biofeedback for well-being in general, and that it does not represent a diagnostic tool anyway. Results obtained from personality tendencies analysis suggest that we need to encourage and empower people's sense of internal control toward their health for promoting a valid use and a proper knowledge of biofeedback. Personality could influence the attitude toward new health technologies, and thus future biofeedback training should be tailored to each individual need. Additional researches are recommended in order to empirically assess the biofeedback application in different populations.

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Contributions: GR, conceived and planned the experiments; GR, SO, carried out the experiment, planned and carried out the simulations; GR, SO, CC, contributed to analyze the data; GR, SO, PG, contributed to the interpretation of the results; GP, supervised the project. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

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Ethics approval and consent to participate: The research protocol was approved by the Institutional Review Board of the University of Milan and the Ethical committee of the European Institute of Oncology IRCCS with respect to scientific content and compliance with applicable research and human subjects' regulations (ethical principles declaration of Helsinki). Participation in the study was voluntary and data collected were anonymized.

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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