Hamburg University of Applied Sciences, Hamburg
Faculty of Life Sciences
Department of Health Sciences
Master of Public Health

Impact Evaluation of Wearable Devices on Physical Activity and Healthy Lifestyles

Master Thesis

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Submitted by: **Opeyemi Ayanwale**
[redacted]

First Supervisor: **Prof. Dr. Andre Klussmann**
Second Supervisor: **Dr. (MPH) Adekunle Adedeji**

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List of Abbreviations

%	Percent
α	alpha
X^2	Chi-square statistics
AI	Artificial Intelligence
App	Application
BCTs	Behavioral Change Techniques
CALO-RE	Coventry, Aberdeen, and London-Refined
CI	Confidence Interval
CDC	Centers for Disease Control and Prevention
DALYs	Disability-adjusted life years
df	degree of freedom
e.g	for example
etc.	et cetera
EU	European Union
H_o	Null Hypothesis
H_1	Alternative Hypothesis
IoT	Internet of things
N/ n	Number / Sample size
NC	North Carolina
NCDs	Noncommunicable Diseases
Min	Minimum
Max	Maximum
PA/PAL	Physical Activity /Physical Activity Level
p	p-value
RKI	Robert Koch-Institut
SPSS	Statistical Package for the Social Sciences
SD	Standard Deviation
WDs/WHDs	Wearable Devices / Wearable Health Devices
WHO	World Health Organization

ABSTRACT

Background and aims: Physical activity is closely linked to health and well-being, but most adults do not meet their recommended daily activity guidelines. More efforts are required to assist people in adopting healthier lifestyles. Several research studies appear to support the use of wearable devices as a tool to influence healthy behaviour change. This study investigates this further by evaluating the efficacy of the wearable devices in influencing lifestyle factors and the psychological impact of these devices on users.

Method: Quantitative data were collected from adult wearable users and non-users living in Hamburg Germany (N = 134) through an online survey. Data on participant demographic characteristics, user experience with their device and non-users' perception of the device were collected and analysed. The outcomes were examined using descriptive statistics, crosstabulation tables and the chi-square test of independence to explore the relationship between wearable device usage and lifestyle factors.

Results: The percentage of participants with sedentary physical activity levels dropped from 22.4% to 1.5% after they started using their wearable devices. The results of chi-square analysis shows that there is a significant relationship between wearable device usage and physical activity, overall health management and adopting healthy behaviours.

Conclusion: The findings indicate that using a wearable is a positive experience with little risk of negative psychological effects. This study also found that adopting healthy lifestyles, such as incorporating more physical activity into daily life depends on usage length, implying that a longer usage time is required to have a greater impact on users physical activity level. The findings of this study contribute to the increasing evidence in support of wearables devices as a potential health behaviours modification tool.

Keywords: Physical activity, Wearable devices, Lifestyle factors, Affective response

1. Introduction

1.1. Background to the Study

A number of factors contribute to the health and risk of disease of an individual, this includes the environment, economic, social conditions, education, lifestyle choices etc, (WHO, 2021). Many lifestyle behaviours, such as alcohol consumption, tobacco use, poor diet, psychological stress and physical inactivity, can increase a person's risk of developing a chronic disease (CDC, 2021). Chronic diseases are estimated to account for nearly 70% of all deaths worldwide, with insufficient physical activity accounting for 1.6 million deaths each year (WHO, 2018b). There is a strong relationship between physical activity, wellbeing and quality of life, as physical activity helps prevent and manage non-communicable diseases (NCDs), maintain healthy body weight, improve mental health, contributes to a better quality of life and wellbeing (Anokye *et al*., 2012; WHO, 2020). The human body has been built to move and thus requires daily physical activity for optimum function and disease prevention (CDC, 2020).

Moreover, an active lifestyle has many other social and psychological advantages. Physical activity and life expectancy are closely related, such that physically active populations appear to live longer than those who are inactive(Reimers *et al*., 2012). Sedentary people who become more physically active report feeling stronger both mentally and physically and have a better quality of life (Maragkoudakis, 2017). The emergence of illnesses and symptoms at all ages may be avoided by a systematic promotion of physical activities. Individuals' lifestyles are increasingly characterized by a lack of extensive physical activity, an unhealthy diet, stress etc., so the focus is now on motivating people to engage in more healthy lifestyles. Poor sleep quality and insufficient sleep are also linked to neurological dysfunction, which increases the risk of obesity

(Spiegel *et al*., 2009), stress, cardiovascular disease and mood disorders (Meerlo *et al*., 2008). To help individuals adopt a healthy lifestyle, new and efficient instruments for changing behaviours are required. One such instrument is the wearable activity tracker. A wearable activity tracker is a lightweight(usually in form of a bracelet) device that tracks health and activities (Haghi *et al*., 2017; Shin *et al*., 2019). These activities include regular steps, stair counts, heart rate, duration of sleep, exercise and sedentary behaviour with information shown to the user through the device itself and corresponding mobile [app] or website (Haghi *et al*., 2017; Shin *et al*., 2019). In a wide variety of fields, wearables have been embraced; however, they do have great potential in healthcare to resolve the increase in healthcare costs and chronic disease burden in aging populations(Milani *et al*., 2016). There is a profound transformation of the healthcare system from a traditional hospital structure to an individual approach, driven by the aging population, chronic disease prevalence, and ever-rising healthcare costs (EU, 2019). Current and new wearable technology would have a revolutionary effect on this paradigm change. Wearable technology will allow users to constantly track their health status for self-health monitoring (Dias & Paulo Silva Cunha, 2018). Wearable technology is anticipated to give healthcare providers enormous benefits. With wearable apps, medical professionals can obtain a deeper understanding of a patient's condition through the data obtained from their wearables, which can be used for a detailed diagnosis (Darshan & Anandakumar, 2015; Wu *et al.,* 2019). Using wearable technology in the healthcare system can also save money. A lack of regular exercise, insufficient sleep, alcohol, drug and tobacco dependence is estimated to be attributed to 20% of all healthcare costs (Richard & James, 2015). Using wearable technology to facilitate greater participation in physical activity and to promote other healthy lifestyles can help individuals and communities get healthy and reduce pressure on the healthcare system.

1.2. Aims and Objectives

The main aim of this study is to explore the impact of wearable devices on physical activities and lifestyle factors. The specific objectives this study intends to achieve are:

I. To assess the efficacy of wearable devices on physical activity and other lifestyle factors.

II. To explore socio-demographic characteristics that influence the usage of wearable devices.

III. To examine user's psychological response to the use of wearable devices.

IV. To explore non-users perceptions of wearable devices on lifestyle changes.

1.3. Research Questions

In line with the stated objectives above, this study seeks to provide answers to the following questions:

I. Does wearable device usage influence physical activity and other lifestyle factors?

II. How do socio-demographic characteristics influence wearables device usage patterns?

III. How do users' affective responses differ when they can use their devices and when they do not use them?

IV. What are the non-users perceptions of wearable devices as tools for influencing lifestyle and overall health?

1.4. Justification for the Study

Due to the expected rise in the aging population, the demand for self-health monitoring and preventive medicine is growing. Lack of physical activity is one of the leading causes of global death in many nations, contributing to the burden of NCDs and impacting global health. Wearable devices such as activity trackers and smartwatches enable users to monitor various aspects of their well-being, nutrition and fitness to track their progress toward their health goals, allowing for a more holistic approach to personalized health. Most fitness trackers can now monitor health metrics such as activity rates, heart rate, sleep quality, among others. Users can track these measures over time by analyzing the data collected by the device, allowing them to identify when problems arise or when things become unusual. It can also influence people to become more active, sleep better and engage in other healthier habits to improve their quality of life. Most trackers have applications where you can track weight and calorie consumption, which helps encourage a balanced diet. The ability to track progress adds a whole new dimension to health and wellness that is unique to wearable devices.

1.5. Thesis Structure

This thesis is divided into six parts. Chapter one focuses on the background to the study, aims of the study, the importance of the study and the study plan. Chapter two focuses on the review of literature, conceptual issues, summary and literature gaps. Chapter three focuses on methodology: research design, data source, research instruments, procedure, data management and data analysis. Chapters four and five centres on the presentation, analysis, interpretation and discussion of the results. Chapter six focuses on the study summary, conclusion, study limitation and future research direction.

1.6. Conceptual Definition of Terms

Wearable Health Devices (WHDs): WHDs are an evolving technology that is intended to constantly track outpatients for human vital signs during their everyday lives (home, work, sports events, etc.) without interfering with regular human events (Dias & Paulo Silva Cunha, 2018).

Wearable Activity / Fitness Trackers: are devices equipped with sensors to monitor physical activity and other health-related measurements. By syncing with supporting applications, they provide health and fitness recommendations to the wearers.

Smartwatch: is a wearable technology worn on the wrist and comes with diverse functionality beyond simple activities tracking. Most smartwatches have supporting applications to track health.

Smart clothing: are clothes that monitor the physical state of the wearer with biometric data such as pulse rate, temperature, muscle stretch, heart rhythm and other physical movements. In real-time, the data is then transmitted to a supporting application through wireless communication.

Non-communicable diseases (NCDs): also known as chronic diseases – are not pass from one person to another, usually last for a longer time and have a variety of genetic, physiological, environmental and behavioural causes (WHO, 2018b).

Physical Activity: any body movement that involves energy expenditure generated by skeletal muscles, including activities carried out while working, playing, performing household chores, traveling and participating in recreational activities (WHO, 2020c).

Vigorous physical activities: these activities can include fast walking, fast cycling, jogging, strenuous swimming or sports, vigorous aerobic dance, or strenuous gardening (CDC, 2019).

Light-moderate physical activities: these can include moderate or leisurely walking or cycling, slow swimming or dancing, and basic gardening (CDC, 2019).

Physical inactivity: is a term used to identify people who do not have at least 150 minutes of moderate-intensity physical activity per week or at the recommended level of regular physical activity.

Sedentary lifestyle: is a lifestyle that requires little to no physical activity. Individuals who live a sedentary lifestyle often sit down or lie down while doing activities such as reading, socializing, watching TV, playing video games, or using a mobile phone/computer for most of the day (Thivel *et al.*, 2018).

2. Literature Review

2.1 Physical Activity and Sedentary Lifestyle

Engaging in regular physical activity is associated with improved health and well-being and a decrease in the risk of developing non-communicable diseases (WHO, 2020b). Regular exercise and physical activity are some of the main factors that influence the quality of life, play an important role in ensuring functional autonomy for aging people and lowering the risk of morbidity and mortality (Paterson & Warburton, 2010) and contribute significantly to the prevention of many chronic diseases e.g. cardiovascular disease, diabetes, cancer, hypertension, obesity, depression and osteoporosis (Warburton *et al.*, 2006).

2.1.1 Effects on health & economic burden

There is substantial evidence that engaging in daily physical activity promotes multiple physical and mental health advantages(Hupin *et al.*, 2015; Liu *et al.*, 2016; Rosenbaum *et al.*, 2014). Sedentary activities and physical inactivity are significant public health problems that raise the risk of chronic diseases and death (Maragkoudakis, 2017). The burden of chronic illness has a significant negative impact on people's quality of life. Physical lifestyle inactivity is a major risk factor associated with several health hazards and remains an important factor for chronic lifestyle disease. These raise the chance of developing chronic health conditions such as cardiovascular disease, type 2 diabetes, obesity, cancers, depression, and anxiety leading to poor mental wellbeing, premature mortality and decreased quality of life (Artemis, 2004; Lee *et al.*, 2012). In the WHO European region, a total of one million deaths (around 10 % of the total), accounting for 8.3 million life-years adjusted to disabilities (DALYs - approximately 5% of the total) are projected to compensate for physical inactivity in the WHO region per year (WHO, 2020a). The population aging around the world is increasing significantly, with the world's population aged 60 years and older predicted to hit 2 billion by 2050, up from 900 million in 2015 (WHO, 2018a). Although the world is rapidly progressing in medical, social and economic terms, however, this progress is insufficient to address the challenges posed by an aging population to society and the healthcare system. The world's healthcare budget remains a disturbing one, with direct (health) and indirect physical inactivity costs (loss of productivity from illness, injuries at work, or premature death) projected to increase. The total burden is estimated at 910 million euros annually in a population of 10 million, with half the population insufficiently active; by 2030 the proportion of deaths due to age-related chronic diseases is expected to rise from 59% in 2002 to 69% (Mathers & Loncar, 2006; WHO, 2020a). Chronic diseases could become our society's most costly financial burden if they are not properly avoided and handled. Increased effort is required to help people to adopt healthy lifestyles as daily physical activity is associated with improved health and well-being as well as a decreased risk of contracting non-communicable diseases (Maragkoudakis, 2017).

2.1.2 Prevalence of physical inactivity and sedentary lifestyle

Despite the recognized benefits of involvement in physical activity, 31% of adults worldwide are inadequately active as they do not meet the recommended requirements of at least 30 minutes of physical activity of moderate intensity on at least 5 days a week or 20 minutes of physical activity of vigorous-intensity on at least 3 days per week or an equal combination of 600 metabolic activities (Hallal *et al.*, 2012). The inactivity often varies significantly across the WHO areas (see Figure 1): inactivity rates in Africa are 27.5% (27.3–27.7), America 43.3% (43.0–43.6), the eastern Mediterranean 43.2% (42.8–43.6), Europe 34.8% (34.5–35.1), Southeast Asia 17.0% (16.8–17.2) and Western Pacific

33.7% (33.5-33.9). Women are (33.9%) more inactive than men (27.9%) (Hallal *et al.,* 2012). By 2025, both WHO and the Global Physical Activity Observatory (GoPA) intend to decrease the global prevalence of physical inactivity in adults by 10% (Hallal *et al.,* 2014; WHO, 2020). The latest global comparative estimate available from 2010 shows that 23% of adults and 81% of adolescents (11-17 years of age) worldwide do not meet the guidelines for global physical activity (WHO, 2019). Globally, about four out of five teenagers aged between 11 and 17 years were under-active in 2016. The prevalence of the boys decreased by 2.5% (important variation) between 2001 and 2016 (from 80.1% to 77.6%) while no major change for girls (from 85.1% to 84.7%), which resulted in a substantial global gap of 7.1% in gender inadequacy in 2016 (Guthold *et al*., 2020).

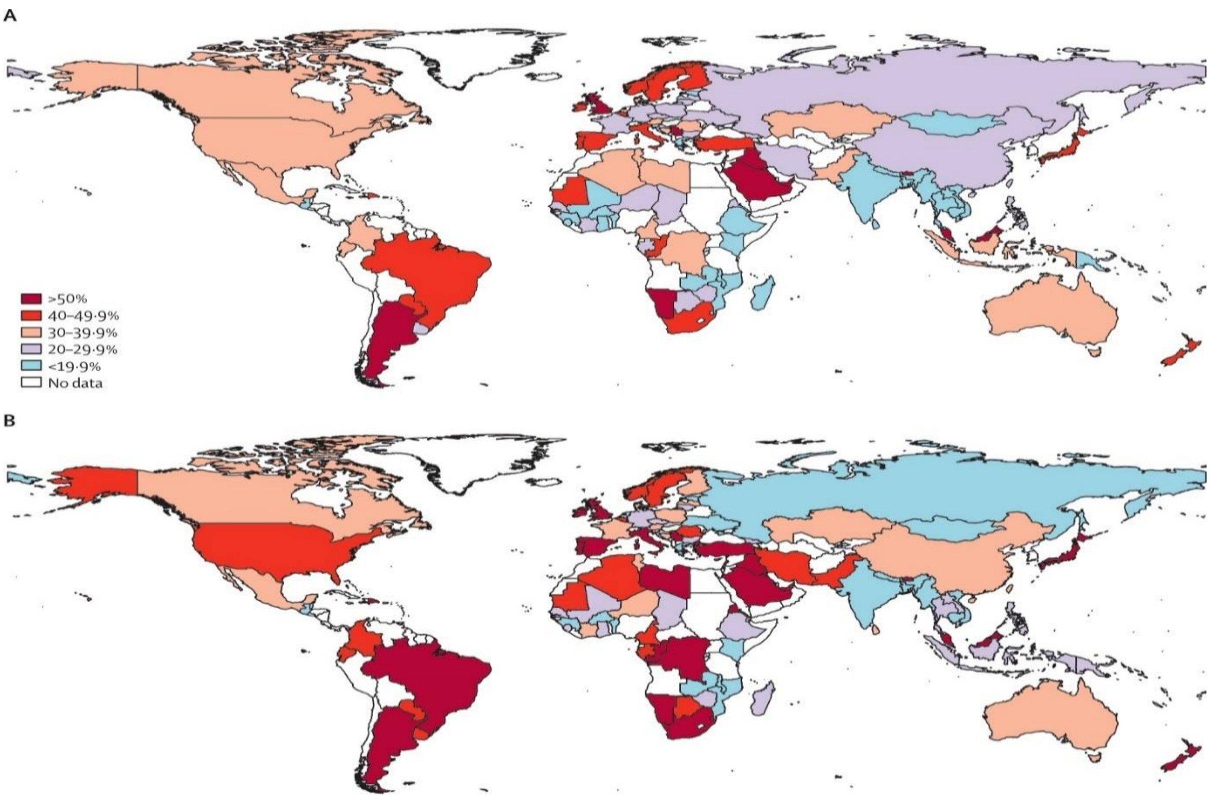


Figure 1. Physical inactivity in adults worldwide in men(A) and women(B).

Note. From "Global physical activity levels: surveillance progress, pitfalls, and prospects," by P.C Hallal, L. B Andersen, F.C Bull, R. Guthold, W. Haskell and U. Ekelund, 2012, *The Lancet, 380(9838*), p. 247-257. (https://doi.org/10.1016/S0 140-6736(12)60646-1). Copyright 2012 by Elsevier Ltd.

Inactivity in all WHO regions increases with age (see Figure 2), which is a trend considered to have a clear biological basis. Adults 60 years of age and older from Southeast Asia are far more active than people of the same age from all other regions and more active than young adults (15–29 years old) from the Americas, the Eastern Mediterranean, Europe and the West Pacific (Hallal et al., 2012). If these trends continue, the global goal of reducing physical inactivity by 10-15% will not be reached by 2025-2030 (Guthold *et al.*, 2020; WHO, 2020). In 2014, just under one-third of adults in the EU reported doing at least 150 minutes of physical activity per week; physical activity decreases with age and increases with education level. EU people typically participate in day-to-day physical activity (such as walking, cycling, climbing stairs, gardening or dancing) more quickly than organized sports (Maragkoudakis, 2017).

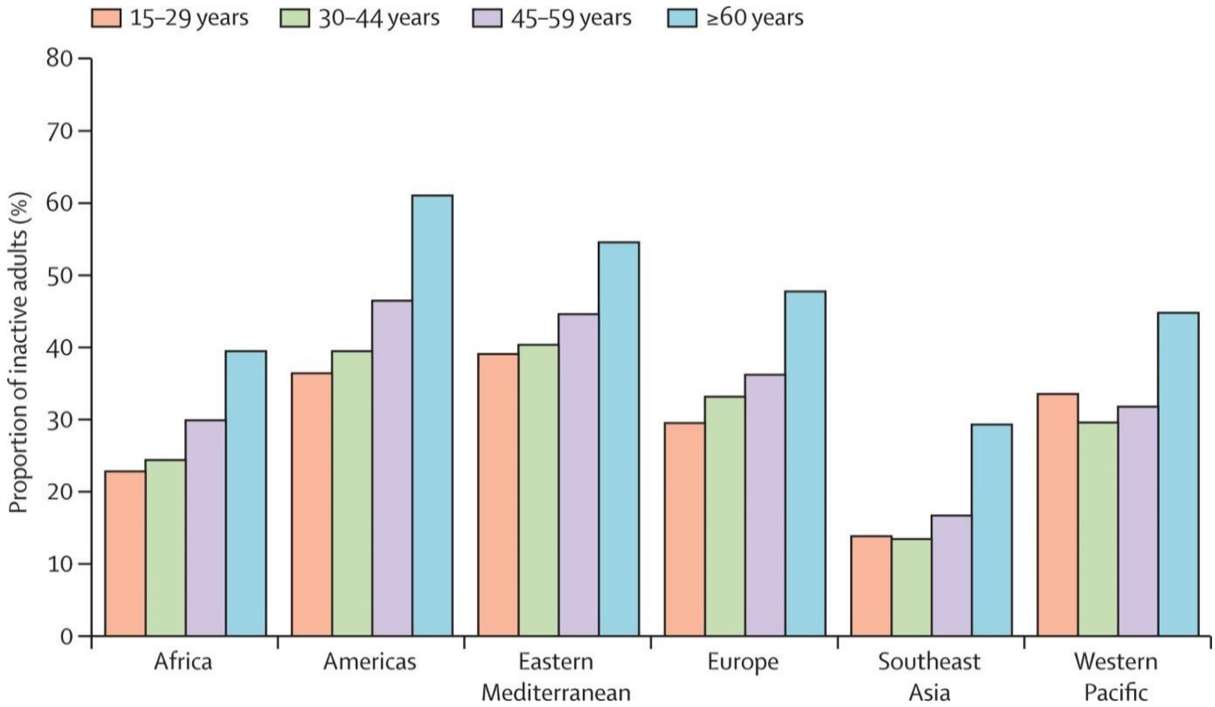


Figure 2. Physical inactivity in age groups by WHO region.

Note. From "Global physical activity levels: surveillance progress, pitfalls, and prospects," by P.C Hallal, L. B Andersen, F.C Bull, R. Guthold, W. Haskell and U. Ekelund, 2012, *The Lancet, 380(9838)*, p. 247-257. (https://doi.org/10.1016/S0140-6736(12)60646-1). Copyright 2012 by Elsevier Ltd.

Sedentary behaviour, which is typically defined as time spent sitting is another aspect of human movement range that has received attention and recently been recognized as a public health issue. Hallal *et al.* (2012) found that 41.5% of adults spend 4 hours or more per day sitting. This number highly varied in WHO regions, in Africa 37.8% of people sit for 4 or more hours per day, 55.2% of people in the Americas, 41.4% of the East Mediterranean, 64.1% of people in Europe, 23.8% of people in South-East Asia and 39.8% of those living in West Pacific sit for 4 or more hours per day. The proportion of individuals spending 4 hours or more per day sitting does not vary significantly for adults aged 15 to 59 years and both genders are the same (see Figure 3).

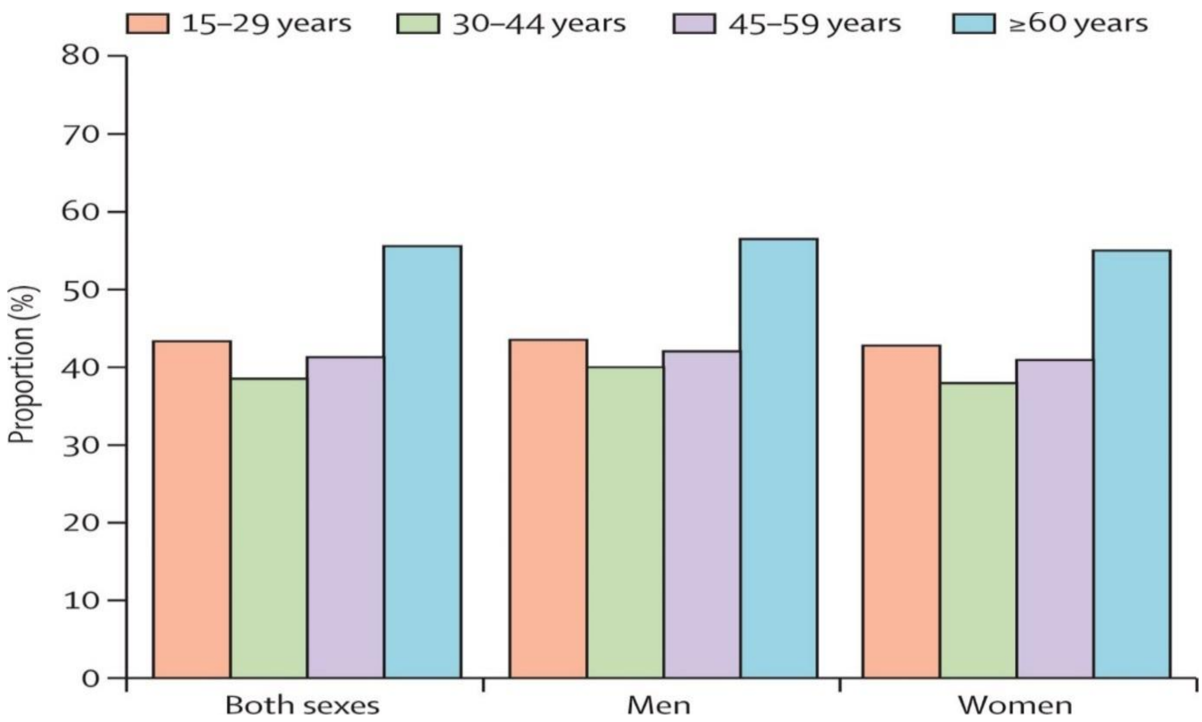


Figure 3. Proportion of individuals reporting 4hr or more of sitting per day by age group.

Note. From "Global physical activity levels: surveillance progress, pitfalls, and prospects," by P.C Hallal, L. B Andersen, F.C Bull, R. Guthold, W. Haskell and U. Ekelund, 2012, *The Lancet*, *380(*9838), p. 247-257. (https://doi.org/10.1016/S0140-6736(12)60646-1). Copyright 2012 by Elsevier Ltd.

2.2 Wearable Activity Tracker and Wearable Fitness Tracker

Wearable activity trackers are new interventions that provide feedback and encouragement for increasing physical activity and health-focused monitoring to minimize sedentary behavior and the risk of developing non-communicable diseases.

2.2.1 Wearable activity tracker as physical activity intervention

Activity trackers are used in research studies and not just in the consumer market. Examples of assessment include a study on adults (Cadmus-Bertram *et al*., 2015; Kononova *et al.,* 2019) in which 51 inactive, postmenopausal women were randomized to a 16-week accelerometer-based self-monitoring physical activity intervention. Over 16 weeks, a high level of self-monitoring was maintained, indicating that a wearable activity tracker is a promising tool for continuous monitoring of physical activity in this population. In another study, 33 adults (22 men, 11 women) were recruited to participate in a new study using a pre-post randomized control trial. Participants were assigned to intervention group (n = 18) or a control group (n = 15). During the four-week cycle, the intervention group worked together with the personal activity monitor while there was no interaction with activity tracker by the control group, they rather follow their usual everyday life habits. The 7-day Sedentary and Light Intensity Physical Activity Log (7-day SLIPA Log) and the International Physical Activity Questionnaire (IPAQ) were evaluated for sedentary time, light, moderate and intense physical activity levels (PALs) in both intervention and control groups at baseline. Participants in the intervention reduced their sedentary time (21%, 2.3 hours / day) and increased their light PAL (36.7%, 2.5 hours / day), moderate PAL (67%, 455 MET-min / week) and intense PAL (60%, 442 MET-min / week) (all $p < 0.001$). No major variations were found for any control group outcome variable (Barwais *et al.*, 2013).

2.2.2 Wearable activity tracker as a multifaceted intervention

Wearable activity trackers are a promising tool for encouraging behavioural change among different demography. A critical analysis was carried out by Mercer *et al.* (2016) to analyse the behavioural change techniques (BCTs) in the latest and emerging wearable trackers technologies, using a taxonomy such as the Coventry, Aberdeen and London-Refined (CALO-RE). The average number of BCTs found from the results was 16.3/40, most frequently used behavioural change techniques in the tested wearable activity trackers, such as self-monitoring and self-regulation strategies, are likely to cater primarily to younger and middle-aged adults. Overall, wearable activity trackers have several BCTs that indicate that physical activity is improving in older adults (Mercer *et al.*, 2016). In another study, wearable fitness trackers were a useful tool for older adults living with chronic diseases such as heart disease, diabetes, arthritis, and osteoporosis. The participants ranged in age from 52 to 84 years old (average 64); 23 (72%) were female, and the mean BMI was 31 kg/m. Five trackers were tested, including a single pedometer (Sportline or Mio) and four wearables (Fitbit Zip, Misfit Shine, Jawbone Up 24 and Withings Pulse). The research was performed in 4 areas: adoption within a comfort zone, self-awareness and targeting, tracking of data objectives and use of wearable activity trackers as healthcare devices. Few participants had been aware of wearable activity trackers before enrolling. Most had also been asked by a doctor to do more exercise and this was cited as a justification for evaluating the products. After the study, none of the participants planned to buy the simple pedometer, citing low precision and data loss, while 73% (N=32) planned to buy a wearable activity tracker (Mercer *et al.*, 2016). A study was conducted by Saarikko *et al.* (2020) to determine the feasibility of continued monitoring of the health parameters (physical activity, sleep and heart rate) of nulliparous women during pregnancy and 1 month after birth using a smart-bracelet and

IoT-based monitoring system. Results show that physical activity decreased by an average of 1793 steps per day from the second trimester to the third trimester and decrease by about 1339 steps in the postpartum period. Sleep time also decreased by an average of 20 minutes from the second trimester to the third trimester and sleep time was reduced by an additional 1 hour after delivery. The average heart rate increased toward the third trimester and reverted to the early pregnancy level during the postpartum period. The effectiveness of wearable activity tracking technology as part of a weight loss program was carried out in another study: a systematic analysis was conducted and the findings indicate that weight loss approaches using activity trackers in the short term (< 6 months) could be a better choice than a generalized weight loss program (Cheatham *et al*., 2018). Generalized physical activity and weight loss intervention can be resource-intensive that hinder maximum participation compared to a personalized weight loss intervention which can easily be achieved using a wearable activity tracker. Naslund *et al.* (2016) conducted a similar study in which they used a Fitbit activity tracker and mobile devices to monitor physical activity and control weight loss in people with poor mental health and obesity over six months in a non-randomized intervention trial. The Fitbits users were very satisfied with devices for 84.7% of their study days on average and said the devices enabled them to be more physically active and helped to achieve everyday goals, however, some of the participants encountered a technical issue.

The result of various studies carried out appears to support wearable devices as a tool to influence healthy behaviour change. This study investigates this further by evaluating the effectiveness of wearable devices in promoting physical activity and other lifestyle factors. It is also important to understand the experiential aspects of the devices, particularly the psychological impact of using a wearable device.

3. Research Methodology

This chapter describes the research design, study population, research instruments, data collection procedure, data management, measures and analysis.

3.1 Research Design and Method

This study adopted a cross-sectional research design using quantitative data. Primary data were collected using an online questionnaire. Data was collected from wearables and non-wearables users, via a standardized questionnaire in English and German. The survey takes an average of 12 minutes to complete.

3.1.1 Sampling and sample design

Non-probability sampling is most appropriate for this study, according to the research pattern. In this study, the convenience sampling method, which includes people who are most accessible to the researcher was used because, it is cost-effective and easy to collect related data (UKEssays, 2018). To determine the required sample size, a power analysis was performed with an effect size of d = 0.5 with 80% power (alpha = 0.05, two-tailed), G*Power suggests 64 participants per group (N = 128) in an independent samples t-test (Bartlett, 2019). This sample size is regarded as feasible for an online questionnaire study.

3.1.2 Eligibility criteria

The participants eligible for this study are current/former wearable and non-wearable users who are at least 18 years of age. The target population includes students in Hamburg and employees of HAW University of Applied Sciences, Hamburg.

3.2 Procedure

To perform the survey, "LimeSurvey" a free and open-source online statistical survey web app that allows the creation and administration of surveys from a web interface (Schmitz, 2021) was used. The structured questionnaire, which was administered online from 3rd-31st March 2021, consisted of 42 items in the form of single/multiple-choice, numerical input and Likert scale questions. The questions were compiled using a rigorous process including expert consultation to confirmed the content validity and conformity with the study objective and concept.

3.2.1 Measures

Demographic Features

The first part of this questionnaire includes the respondent's demographic data such as gender, age, education and occupation. Participants choose the country they reside in (German State and others), they indicate their age in years, whether they are male or female, their level of education (high school, trade/vocational school, bachelor's degree/interim diploma, master's degree/diploma/state examination, PhD/higher) and the primary occupation group they belong to (mangers, professionals, elementary occupations, retired, students, unemployed individuals etc).

User's experience and perceptions of wearable devices

The second part examined the user's experience and perceptions of wearable devices at the expectation phase, initial use and prolong use phase. Single and multiple-choice questions were used to collect information from users about the type of wearable device they use or have used. Furthermore, data on how they obtained their devices, the frequency of use, motivation and their daily goal were also collected. To assess users' experiences with their devices at various stages of use, a 4-point Likert scale for frequency (never, occasionally, frequently and always) was used to assess the frequency of use and frequency of checking feedback.

Physical activity level and other lifestyle factors

The third part was to gather information on how wearable devices can influence user's physical activity level and other lifestyle factors. The level of expectation and perceived impact of wearable usage on diet, sleep, stress level, overall health management and physical activity level are assessed using Likert items, which indicate users' level of expectation and degree of agreement/disagreement with the perceived change in their lifestyles. To quantify users' physical activity level in this study, the International Physical Activity Questionnaire (IPAQ) classification of physical activity was adapted (IPAQ, 2005; Strath et al., 2013). Physical activity levels are classified as follows: "sedentary" (no moderate or vigorous activities / less than 30 minutes of intentional exercise or activities per day), "lightly active" (daily exercise that is equal to walking for 30 minutes / 15 - 20 minutes of vigorous activity on daily), "active" (daily exercise that is equal to walking for 1 hour and 45 minutes / 50 minutes of intense exercise per day) and "very active" (daily exercise that is equal to walking for 4 hours and 15 minutes / 2 hours intense exercise per day).

Affective responses

The fourth part was dedicated to gathering information about users' affective responses to their wearable devices when they are able/unable to use them, using an 8-item scale (positive and negative affect scale). There were four items asking participants to state to what extent "when I use my wearable I am feeling [cool, accountable, empowered, motivated] and four items that asked the participants to say to what extent "I feel [anxious, guilty, frustrated, unmotivated] if I am not using/forget/can't wearable." Participants were asked to indicate the amount to which they agreed that they had experienced a certain emotional state or feeling during a given time frame, with responses assessed on a 5-point Likert scale (ranging from strongly disagree to strongly agree).

Non-users general perceptions of a wearable device

The fifth part was to gather information on non-users general perceptions of a wearable device. Non-users perceptions and factors that contribute to wearable device adoption were assessed using single and multiple-choice questions. Non-users perceptions of wearables as a motivational tool in lifestyle and behavior change were measured using a 5-point Likert scale (ranging from strongly disagree to strongly agree).

Non-users physical activity level and lifestyles changes

The last part of the questionnaire was dedicated to gathering information about non-users PAL, changes in lifestyles in the last 12 months and comparing it with users PAL and changes in lifestyles.

3.3 Data Analysis

Data collection occurred over four weeks. All data were downloaded into the statistical software package SPSS (IBM, V27) for analysis. The data analysis process included data processing, i.e., deleting unnecessary variables (such as start time, date stamp and language), adding labels, transforming and renaming some variables. Data were also screened for outliers and normality before analysis using histograms and normal Q-Q plots. Descriptive statistics were used to analyze the characteristics of the study participants, frequency of use, usage pattern, change in usage over time, usage intention, and non-users perception of wearable devices. To assess the relationship between the use of wearable devices and socio-demographic characteristics, crosstab was generated. To test for a statistically significant relationship between socio-demographic characteristics and frequency of usage following a period of protracted use, a Chi-square test of independence was performed. Chi-square test of independence was also carried out to test for a statistically significant relationship between wearable device usage and lifestyle factors such as diet, sleep patterns, general health and physical activity. The statistical significance level which is the probability of rejecting null hypothesis is set at .05. This study uses tables, figures and percentages in the presentation and analysis of the data.

4. Results

4.1 Descriptive Statistics of Participants and Survey

A total of 327 people participated in the survey, with 255 providing complete responses and 72 providing incomplete responses. Among the 255 completed samples, 134 are students and employees in Hamburg, with the remaining 121 coming from other states in Germany and abroad. Since the target population are Hamburg residents, these 121 respondents are excluded from the data analysis. As a result of meeting the eligibility criteria and required sample size, 134 of the complete responses were included in the final analysis.

The participants' average age is 28.05 years (SD 7.68 years), with 81 females and 52 males. About 56.7% of the population is between the ages of 25 and 39, 37.3 percent is between the ages of 18 and 24, 5.2 percent is between the ages of 40 and 59, and 0.7 percent is 60 and older. Approximately 77 percent of the participants are students (103) and 13.4 percent are professionals (18). Fifty-one (38.1%) of the participants had completed high school and fifty-one (38%) had at least some postsecondary education, with twenty-nine (21.6%) pursuing postgraduate and three (2.2%) having completed some other degree of education. The most common age group is 25-39, with a minimum age of 18 and maximum age of 65 and most of the respondents (81) are females (see Table 1). Furthermore, the questionnaire was mostly circulated to HAW (Hamburg University of Applied Sciences) students, which may explain why a significant proportion of the sample is made up of young students.

Table 1

Sample characteristics of participants

Variable	Category	Frequency	Percent (%)
Gender	Female	81	60.4
	Male	52	38.8
	Prefer not to say	1	0.7
	Divers	0	0.1
Age(grouped)	18-24	50	37.3
	25-39	76	56.7
	40-59	7	5.2
	60+	1	0.7
Occupation	Students	103	76.9
	Professionals	18	13.4
	Others	13	9.4
Education	High School	51	38.1
	Trade School / Vocational School	9	6.7
	Bachelor's / Interim Diploma (or equivalent)	42	31.3
	Master's degree / Diploma state (or equivalent)	27	20.1
	PhD or higher	2	1.5
	Others	3	2.2

Note. N= 134. Participants were on average 28.05 years old (SD = 7.68)

4.2 Wearable Device Frequency of Use and Usage Pattern

This section displays data on users' experiences with their wearable devices, including frequency, the pattern of usage and motivation for use. Tables 2 and 3 present the percentages of wearable device users versus non-users, as well as the type of wearable device they use.

4.2.1 Types of wearable device

Among 134 respondents, 67 (50%) have never used any type of wearable device and 67 (50%) have used fitness/activity trackers and smartwatches (57 current users and 10 former users) (see Table 2). The percentage of smartwatches users in this study is about 53% and the percentage of fitness/activity tracker users is 47.1% (see Table 3).

Table 2

Percentage of wearable device users and non-users

Do you use a wearable device e.g., pedometer etc	N	Percent (%)
No, never	67	50.0%
No, but I used to have one	10	7.5%
Yes, I'm currently using a wearable	57	42.5%
Total	134	100%

Table 3

Types of wearable device users have or have used

Types of Wearable Device	N	Percent (%)
Fitness Tracker/Activity Tracker	32	47.1%
Smartwatch	36	52.9%
Total	68	100.0%

4.2.2 Mode of acquisition and length of use

A noticeable number of users obtained their wearable device on their own (30%) or as a gift (19.4%), while a small percentage (0.7%) obtained it through their health insurance (see Table 4). About 19.4% of users have used their wearables for about 6 months or less, while 10.4% have been using them for 7-12 months however, only about 3% of users have used their wearable device for more than 36 months (see Table 5). The observed minimum length of usage is 1 month, and the maximum length is 60 months (5 years), with an average length of usage of 15.55 months (see Table 5).

Table 4

How users got their wearable device

Mode of acquisition		N	Percent (%)
I bought it myself		40	29.9%
As a Gift		26	19.4%
Provided by the health insurer		1	0.7%
Missing	System	67	50.0%
Total		134	100.0%

Table 5

Length of use

Length of use (in month)	N	Percent (%)
1 – 6	26	19.4%
7 – 12	14	10.4%
13 - 18	4	2.9%
19 – 24	9	6.7%
25 – 30	5	3.7%
31 – 36	5	3.7%
37 – 42	1	0.7%
43 – 48	2	1.5%
49 – 54	0	0%
55 – 60	1	0.7%
Missing System	67	50.0%
Total	134	100.0%

Note. N= 134, Mean (Average)= 15.55, Minimum month of usage =1, Maximum month of usage= 60.

The results show that the majority of users (46) wear their devices every day, 14 use their device a few days a week, a few use it once a week/month/year, and a few only use it when training (see Figure 4). As a result, in the following section, we will look at user motivation for using a wearable device and how usage changes over time.

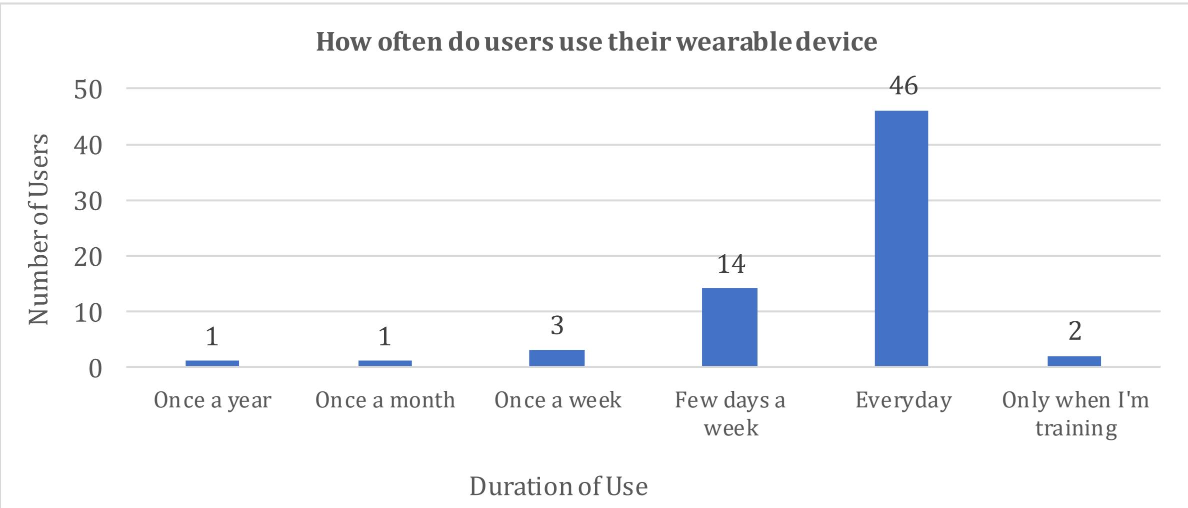


Figure 4. Duration of use.

4.3 Wearable Device Usage Intention and Change in Usage Overtime

This section displays data on users' primary reasons for using wearable devices, daily goals and frequency of checking collected information from their wearable device, during the initial use period and change in usage after prolonged use.

4.3.1 Motivation for using wearable devices

Approximately 25% of users use their wearable to monitor their activities, 15% of users use it to improve their health and fitness, 5.2% of users just want to keep up with new technology, 4.5% of users use it for weight loss, and 0.7% of users use it to improve their appearance (see Figure 5).

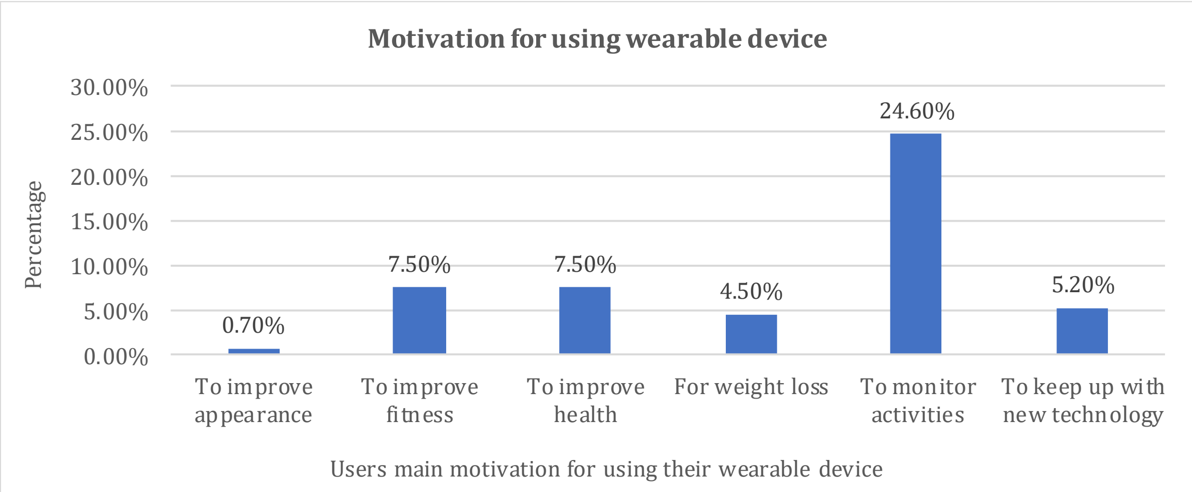


Figure 5. Users' motivation for usage.

4.3.2 Goal setting

According to the findings of this study, a large proportion of wearable device users (42.6%) set daily goals for themselves, while (7.50%) of users do not (see Figure 6). Approximately 42% of users' daily goals are to track steps count, 18% of users' daily goals are to monitor active time, 14.2% of users' daily goals are to track calories burned, 13.3% of users' daily goals are to monitor their sleeping patterns, 8.3% of users' daily goals are to monitor general health status, 4.2% of users' daily goals are to monitor other activities i.e. multisport and 0.8% of users' daily goals are to track calories consumption (see Table 6).

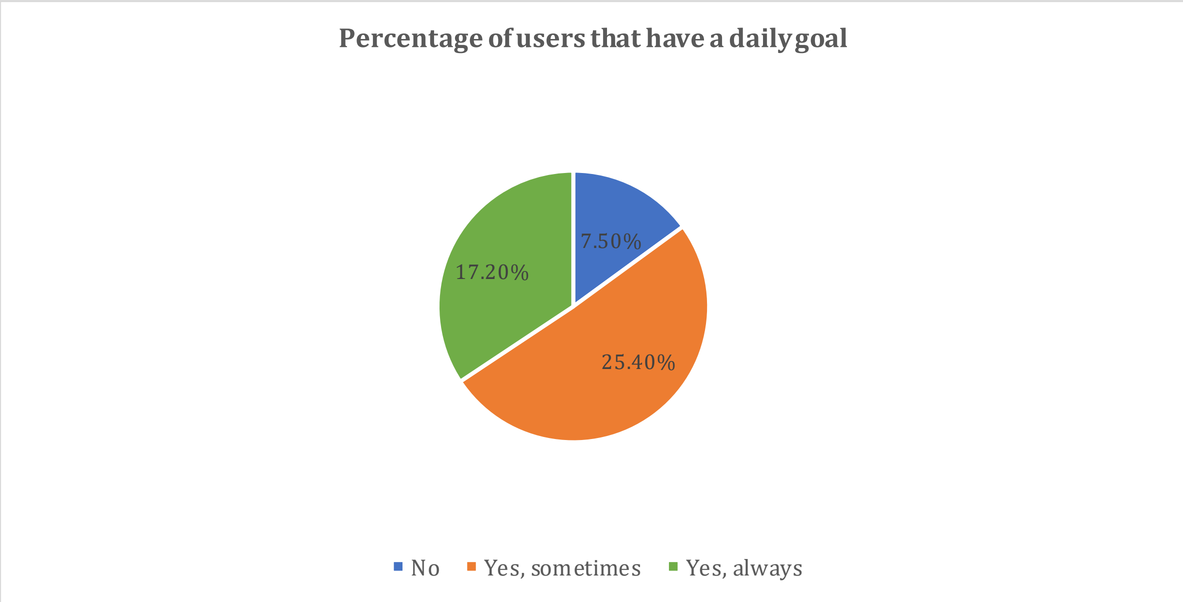


Figure 6. Percentage of users that set a daily goal.

Table 6

Users' daily goals specified

Users Daily Goals	**N**	**Percent**
Activity: Active time	21	17.5%
Steps: Walk & Distance	50	41.7%
Sleep: Record & Analyse	16	13.3%
Calories burned	17	14.2%
Calories consumption (food & water)	1	0.8%
Multi-Sport: Running+ Swimming + Cycling+ Cross Training	5	4.2%
General health status: Stress level + Heart rate + Blood glucose + Blood pressure + Saturation level	10	8.3%
Total	120	100.0%

Collectively, 63.4 % of users in this study use their wearable to monitor one or more types of physical activity than in other metrics such as calorie estimation, sleep and general health status.

4.3.3 Change in usage pattern over time

A substantial number of wearable device users (41%) use their wearable device all the time when they first start using it, but after a while, only (27.6%) of users use it all the time but the number of people who use it more often after a while increases by (2.2%). After a prolonged usage period, the number of users who use it sometimes increases from 0.7% to 6.0% and the number of users who never use it increases from 0.1% to 6.0% (see Figure 7).

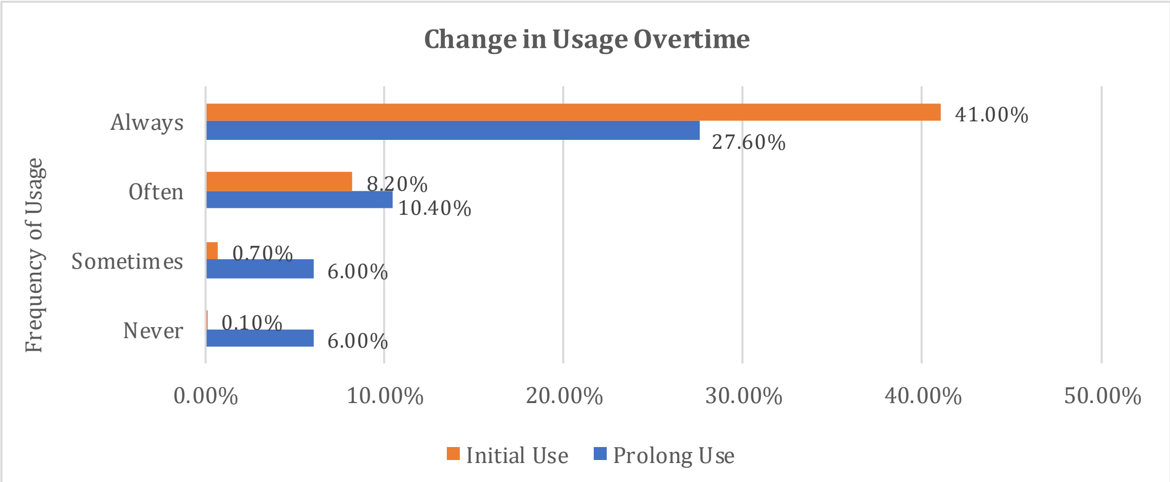


Figure 7. Change in usage over time.

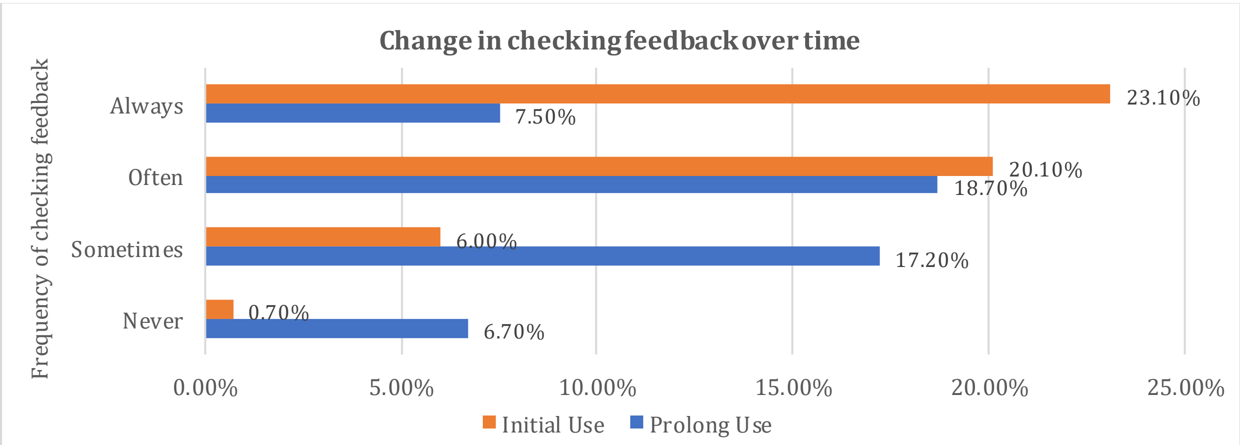


Figure 8. Change in checking feedback over time.

The number of users who always look at the collected information from their wearable in the first week of use was (23.1%) but after a while, only (7.5%) of users maintain this attitude and the number of users who check feedback more often after a while decreases by (1.4%). After a long period of use, the number of users who check feedback occasionally increases from 6.0% to 17.2% and the number of users who never use it increases from 0.7% to 6.7 % respectively (see Figure 8).

4.4 Relationship Between Wearable Device Usage and Lifestyle Factors

This section presents the findings of an evaluation of the relationship between the use of wearable devices and perceived impact on lifestyles using Crosstabulation, the Chi-square test of independence and the Fisher's exact test.

4.4.1 Users' expectations and perceived impact on physical activity level

Table 7

Incorporate more physical activities

To what extent did users expect wearable device to impact their lifestyle		**Incorporate more physical activities in my everyday life**					**Total**
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
Not at all	Count	2	1	4	2	1	10
	Expected Count	.4	.7	2.4	5.1	1.3	10.0
	% Within	20.0%	10.0%	40.0%	20.0%	10.0%	100.0%
To some extent	Count	1	3	10	18	3	35
	Expected Count	1.6	2.6	8.4	17.8	4.7	35.0
	% Within	2.9%	8.6%	28.6%	51.4%	8.6%	100.0%
To a moderate extent	Count	0	1	2	12	4	19
	Expected Count	.9	1.4	4.5	9.6	2.6	19.0
	% Within	0.0%	5.3%	10.5%	63.2%	21.1%	100.0%
To a great extent	Count	0	0	0	2	1	3
	Expected Count	.1	.2	.7	1.5	.4	3.0
	% Within	0.0%	0.0%	0.0%	66.7%	33.3%	100.0%

About 67% of users who expected wearable devices to have a substantial impact on their lifestyle agree to have incorporated more physical activities into their daily lives, while 33.3% strongly agree. For users who expected wearable devices to have a moderate impact on their lives, 63.2% agree and 21.1% strongly agree to have incorporated more physical activities. Users who expect wearable devices to have some impact on their lifestyle, 51.4% agree and 8.6% strongly agree to have included more physical activities in their daily lives, whereas 28.6% are indifferent. Of users who do not expect wearable devices to alter their lifestyle, 40% are indifferent about adopting additional physical activities into their daily lives, while 20% agree and disagree and 10% strongly agree and disagree, respectively (see Table 7).

The percentage of users with sedentary physical activity level dropped from 22.4% to 1.5% after they started using their wearable devices. Before the use of their wearable device, 37.3% of users were lightly active; this number dropped to 32.8% after they began using their wearable device; 34.4% of users were active before they began using their wearable device and 59.7% of users became active after they began to use their wearable device. No difference was observed between users who were very active before and after they began using their wearable device (see Figure 9).

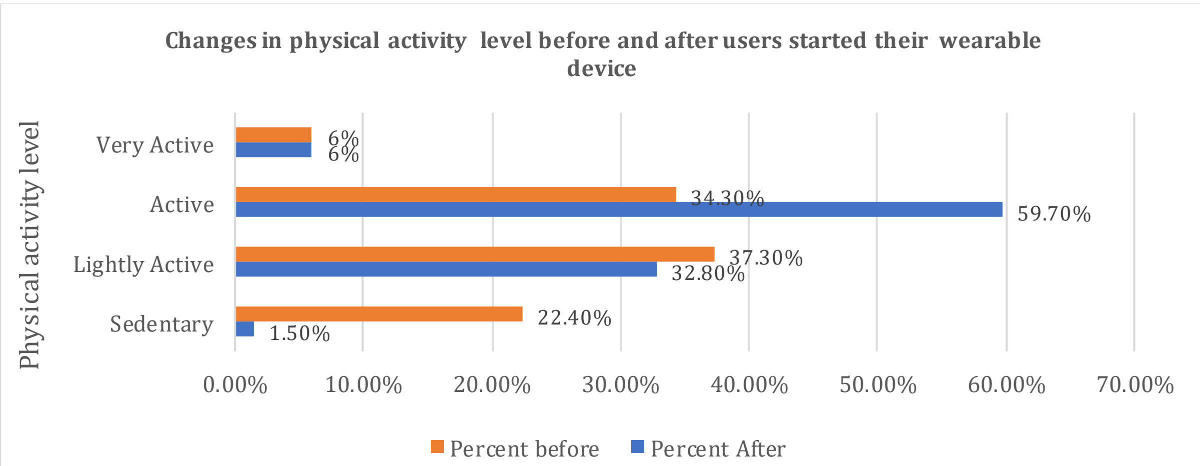


Figure 9. Changes in users' PALs before and after they began using a wearable device.

4.4.2 Users' expectations and perceived impact on lifestyle factors

The findings of this study reveal that 33.3% of users who expected a wearable device to have a significant impact on their eating and consumption habits agree or strongly agree that they have been consuming healthily. Users who do not expect their wearable device to influence their diet disagree (50%) and strongly disagree (40%) that they have been eating or consuming healthier (see Table 8).

Table 8

Eat and consume healthier

To what extent did users expect wearable device to impact their lifestyle		**Eat and consume healthier**					**Total**
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
Not at all	Count	4	5	4	1	0	10
	Expected Count	1.9	3.0	3.4	1.2	.4	10.0
	% Within	40.0%	50.0%	10.0%	0.0%	0.0%	100.0%
To some extent	Count	7	11	13	3	1	35
	Expected Count	6.8	10.4	12.0	4.2	1.6	35.0
	% Within	20.0%	31.4%	37.1%	8.6%	2.9%	100.0%
To a moderate extent	Count	2	4	8	4	1	19
	Expected Count	3.7	5.7	6.5	2.3	.9	19.0
	% Within	10.5%	21.1%	42.1%	21.1%	5.3%	100.0%
To a great extent	Count	0	0	1	1	1	3
	Expected Count	.6	.9	1.0	.4	.1	3.0
	% Within	0.0%	0.0%	33.3%	33.3%	33.3%	100.0%

The findings of this study also show that a substantial number of users agree (33.3%) and strongly agree (33.3%) to have been sleeping better since they started using their wearable device. A high percentage of users with no expectation strongly disagree (60%) and disagree (20%) with the device helping them in improving their sleep patterns. Similarly, 47.4% of users with moderate expectations and 45.7% of users with low-

Table 9

Improve sleeping pattern

To what extent did users expect wearable device to impact their lifestyle		Sleep better					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
Not at all	Count	6	2	2	0	0	10
	Expected Count	1.8	2.5	4.2	.9	.6	10.0
	% Within	60.0%	20.0%	20.0%	0.0%	0.0%	100.0%
To some extent	Count	5	10	16	2	2	35
	Expected Count	6.3	8.9	14.6	3.1	2.1	35.0
	% Within	14.3%	28.6%	45.7%	5.7%	5.7%	100.0%
To a moderate extent	Count	1	5	9	3	1	19
	Expected Count	3.4	4.8	7.9	1.7	1.1	19.0
	% Within	5.3%	26.3%	47.4%	15.8%	5.3%	100.0%
To a great extent	Count	0	0	1	1	1	3
	Expected Count	.5	.8	1.3	.3	.2	3.0
	% Within	0.0%	0.0%	33.3%	33.3%	33.3%	100.0%

expectations feel indifferent about wearable devices improving their sleep patterns (see Table 9). Another variable of interest is stress level; about 43% of users with low expectations are indifferent about the impact of wearable device usage on their stress level, 34.3% disagree and 8.6% strongly disagree that they have been managing their stress level better since using their device. Similarly, 20% are indifferent, 40% disagree and 40% strongly disagree that they have been managing their stress level better among users who have no expectations. Around 33.3% of users who expected a wearable device to have a great impact on their stress level agree or strongly agree to have been managing their stress level better, while 33.3% are neutral. Furthermore, 26.3% of users who expected a wearable device to have a moderate impact on their stress level agree that it did, compared to 36.8% who are neutral, 26.3% who disagree and 10.5% who strongly disagree (see Table 10).

Table 10

Stress Management

To what extent did users expect wearable device to impact their lifestyle		**Manage stress level better**					**Total**
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
Not at all	Count	4	4	2	0	0	10
	Expected Count	1.3	3.1	3.7	1.3	.4	10.0
	% Within	40.0%	40.0%	20.0%	0.0%	0.0%	100.0%
To some extent	Count	3	12	15	3	2	35
	Expected Count	4.7	11.0	13.1	4.7	1.6	35.0
	% Within	8.6%	34.3%	42.9%	8.6%	5.7%	100.0%
To a moderate extent	Count	2	5	7	5	0	19
	Expected Count	2.6	6.0	7.1	2.6	.9	19.0
	% Within	10.5%	26.3%	36.8%	26.3%	0.0%	100.0%
To a great extent	Count	0	0	1	1	1	3
	Expected Count	.4	.9	1.3	.3	.2	3.0
	% Within	0.0%	0.0%	33.3%	33.3%	33.3%	100.0%

The findings of this study also show that 33.3% of users who expected a wearable device to greatly assist them in managing their overall health agree or strongly agree, while 33.3% are neutral about the device's ability to help them manage their overall health. Similarly, 31.6% of users who expected a wearable device to have a moderate impact on their health agree that their health was managed better compared to 42.1% who are neutral, 10.5% who disagree and 5.3% who strongly disagreed. And 71.4% of users with low expectations are indifferent about the impact of the device on their health, with 8.6% disagreeing, 2.9% strongly disagreeing that they have been managing their health well since using their device. Furthermore, 10% of users with no expectations are indifferent about the device's ability to improve their health, 20% disagree and 30% strongly disagree that they have been managing their health better since they began using the device (see Table 11).

Table 11

General health management

To what extent did users expect wearable device to impact their lifestyle		Manage general health better					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
Not at all	Count	3	2	1	3	1	10
	Expected Count	.7	1.0	5.1	2.2	.9	10.0
	% Within	30.0%	20.0%	10.0%	30.0%	10.0%	100.0%
To some extent	Count	1	3	25	5	1	35
	Expected Count	2.6	3.7	17.8	7.8	3.1	35.0
	% Within	2.9%	8.6%	71.4%	14.3%	2.9%	100.0%
To a moderate extent	Count	1	2	8	6	2	19
	Expected Count	1.4	2.0	9.6	4.3	1.7	19.0
	% Within	5.3%	10.5%	42.1%	31.6%	10.5%	100.0%
To a great extent	Count	0	0	0	1	2	3
	Expected Count	.2	.3	1.5	.7	.3	3.0
	% Within	0.0%	0.0%	33.3%	33.3%	33.3%	100.0%

As shown in Table 12, 66.7% of users who expected a wearable device to have a significant impact on their lifestyle agree to have adopted healthy behaviours into their everyday lives, while 33.3% strongly agree. Users who expected wearable devices to have a moderate impact on their lives, 57.9% agree, 15.8% strongly agree to have incorporated healthy behaviours into their everyday lives, while 21.1% are indifferent and 5.3% disagree. And for users who expect wearable devices to have some impact on their lifestyle, 48.6% agree and 8.6% strongly agree that they have incorporated healthier behaviour into their everyday lives, whereas 25.7% are indifferent, 14.3% disagree, and

2.9% strongly disagree. Among users who do not expect wearable devices to change their lifestyle, 10% are indifferent about adopting healthy behaviours into their daily lives, while 20% agree, 10% strongly agree, 30% strongly disagree and disagree, respectively (see Table 12).

Table 12

Incorporate healthy routines

To what extent did users expect wearable device to impact their lifestyle		**Incorporate healthy routines into everyday life**					**Total**
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
Not at all	Count	3	3	1	1	2	10
	Expected Count	.6	1.3	2.1	4.5	1.5	10.0
	% Within	30.0%	30.0%	10.0%	10.0%	20.0%	100.0%
To some extent	Count	1	5	9	17	3	35
	Expected Count	2.1	4.7	7.3	15.7	5.2	35.0
	% Within	2.9%	14.3%	25.7%	48.6%	8.6%	100.0%
To a moderate extent	Count	0	1	4	11	3	19
	Expected Count	1.1	2.6	4.0	8.5	2.8	19.0
	% Within	0.0%	5.3%	21.1%	57.9%	15.8%	100.0%
To a great extent	Count	0	0	0	1	2	3
	Expected Count	.2	.4	.6	1.3	.4	3.0
	% Within	0.0%	0.0%	0.0%	33.3%	66.7%	100.0%

4.4.3 Test of independence between lifestyle factors and wearable device usage

The results of the Chi-square test of independence and Fisher's exact test carried out using the hypothesis below, to determine the statistically significant association between wearable device usage and lifestyle factors are presented in this section. Chi-square results are reported in the following format: X^2 (degree of freedom(df), N = sample size) = chi-square statistic value, p = p-value. The statistical significance level which is the probability of rejecting the null hypothesis when it is true is set at .05.

TEST OF HYPOTHESIS

$\boldsymbol{H_0}$: There are no relationships between lifestyle factors and wearable device usage length

Vs

$\boldsymbol{H_1}$: There are relationships between lifestyle factors and wearable device usage length

DECISION RULE: reject H_0 if p-value$\leq \alpha$, otherwise do not reject H_0 (sig. level = .05)

Table 13

Chi-Square test of independence of lifestyle factors and wearable device usage length

Chi-Square Tests					
Lifestyle factors		**Value**	**df**	**Asymptotic Significance (2-sided)**	**Exact Sig. (2-sided)**
Incorporate more Physical Activity	Pearson Chi-Square	49.479[a]	20	.000	.007
	Fisher-Freeman-Halton Exact Test	32.378			.010
Eat & Consume Healthier	Pearson Chi-Square	15.374[a]	20	.755	.717
	Fisher-Freeman-Halton Exact Test	20.472			.491
Sleep Better	Pearson Chi-Square	25.084[a]	20	.198	.232
	Fisher-Freeman-Halton Exact Test	25.130			.104
Manage Stress level	Pearson Chi-Square	27.725[a]	20	.116	.155
	Fisher-Freeman-Halton Exact Test	23.683			.199
Mange General Health	Pearson Chi-Square	36.588[a]	20	.013	.028
	Fisher-Freeman-Halton Exact Test	23.950			.187
Incorporate *Healthy Behaviour*	Pearson Chi-Square	41.246[a]	20	.003	.010
	Fisher-Freeman-Halton Exact Test	24.995			.101

Note. 26 cells (86.7%) have an expected count less than 5. The minimum expected count is .06.

The Chi-square test of independence between wearable device usage time and improved eating habits, sleeping patterns and stress management revealed no statistically significant relationship, X^2 (20, N=67) = 15.374, 25.084, 27.725, p = .755, .198 and .116. Similarly, Fisher's exact test found no statistically significant relationship between wearable device usage and eating habits, sleeping patterns or stress management (p=.491,.104, .199). Together, from the two statistical tests, we may conclude that lifestyles factors including eating habits, sleeping patterns, stress management are independent of usage, we therefore accept our null hypothesis.

A Chi-square test of independence between wearable device usage time, physical activity overall health management and incorporating healthy routines into everyday lives, on the other hand, revealed a statistically significant relationship, X^2 (20, N=67) = 49.479, 36.588, 41.246, p = .000, .003 and .013. Similarly, Fisher's exact test found a statistically significant relationship between wearable device usage time and increasing physical activity in one’s daily life (p=.010). We may conclude that adopting healthy behaviours, managing overall health and incorporating more physical activity into daily life are dependent on usage length, hence reject our null hypothesis (see Table 13).

4.5 Relationship Between Wearable Device Usage and Socio-Demographic

The results of the evaluation of the relationship between the use of wearable devices and sociodemographic characteristics using Crosstabulation, Chi-squared test of independence and Fisher’s test are presented in this section. The Chi-square test of independence and Fisher’s test were performed to examine whether there is a statistically significant association between socio-demographic characteristics and frequency of usage following a period of protracted use using the hypotheses below. Social demographic characteristics that were considered for this analysis are gender (two levels), age groups (three levels) and level of education (five levels).

Table 14

Crosstabulation of wearable device usage by gender

FREQUENCY OF USAGE (Prolong used)		**Gender**		**Total**
		Female	**Male**	
Never	Count	6	2	8
	Expected Count	5.9	2.1	8.0
	% Within Usage	75.0%	25.0%	100%
Sometimes	Count	3	5	8
	Expected Count	5.9	2.1	8.0
	% Within Usage	37.5%	62.5%	100%
Often	Count	11	3	14
	Expected Count	10.2	3.8	14.0
	% Within Usage	78.6%	21.4%	100%
Always	Count	29	8	37
	Expected Count	27.1	9.9	37.0
	% Within Usage	78.4%	21.6%	100%

The findings show that the number of females differs significantly from the number of males among wearable device users who never, frequently, or always use their device. Whereas among users who use their device only occasionally, the number of males is significantly higher than the number of females. Female users in this study had a higher frequency of usage after a long period of time than male users (see Table 14).

TEST OF HYPOTHESIS

$\boldsymbol{H_0}$: Frequency of usage is independent of gender.

Vs

$\boldsymbol{H_1}$: Frequency of usage is dependent on gender

DECISION RULE: reject H_0 if p-value$\leq$ α, otherwise do not reject H_0 (sig. level = .05)

The Chi-square test of independence between frequency of usage and gender revealed no statistically significant relationship, X^2 (3, N=67) = 5.913, p=.116. Similarly, Fisher's exact test revealed that there was no statistically significant relationship between frequency of usage and gender (p=.156). We may conclude that frequency of usage is independent of gender, we therefore accept our null hypothesis (see Table 15).

Table 15

Chi-square test of independence by gender

Chi-Square Tests						
	Value	**df**	**Asymptotic Significance (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**	**Point Probability**
Pearson Chi-Square	5.913[a]	3	.116	.118		
Likelihood Ratio	5.213	3	.157	.250		
Fisher-Freeman-Halton Exact Test	5.268			.156		
Linear-by-Linear Association	1.359[b]	1	.244	.302	.152	.051
No of Valid Cases	67					
a. 3 cells (37.5%) have an expected count less than 5. The minimum expected count is 2.15.						
b. The standardized statistic is -1.166.						

Table 16

Crosstabulation of wearable device usage by age group

FREQUENCY OF USAGE (Prolong used)		**Age Group**			**Total**
		18-24	**25-39**	**40-59**	
Never	Count	1	7	0	8
	Expected Count	3.2	4.2	.6	8.0
	% Within Usage	12.5%	4.2%	0.0%	100%
Sometimes	Count	2	4	2	8
	Expected Count	3.2	4.2	.6	8.0
	% Within Usage	25.0%	50.0%	25.0%	100%
Often	Count	8	5	1	14
	Expected Count	5.6	7.3	1.0	14.0
	% Within Usage	57.1%	35.7%	7.1%	100%
Always	Count	16	19	2	37
	Expected Count	14.9	19.3	2.8	37.0
	% Within Usage	43.2%	51.4%	5.4%	100%

The crosstabulation of wearable devices by age shows that the frequency of usage varies significantly by age group, a high proportion of users in the age groups 18-24 and 25-39 use their wearable more frequently and always than users in the age group 40-59, whereas the number of users in the age groups 18-24 and 40-59 who use their device occasionally is half that of users in the age group 25-29 (see Table 16).

TEST OF HYPOTHESIS

$\boldsymbol{H_0}$: Frequency of usage is independent of age group.
Vs
$\boldsymbol{H_1}$: Frequency of usage is dependent on age group

DECISION RULE: reject H_0 if p-value$\leq \alpha$, otherwise do not H_0 (sig. level = .05)

A Chi-square test of independence between frequency of usage and age groups revealed no statistically significant relationship, X^2 (6, N=67) = 9.819, p=.132. Similarly, Fisher's exact test revealed that there was no statistically significant relationship between frequency of usage and age groups (p=.151). We may conclude that frequency of usage is independent of age groups, we therefore accept our null hypothesis (see Table 17).

Table 17

Chi-square test of independence by age group

Chi-Square Tests						
	Value	**df**	**Asymptotic Significance (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**	**Point Probability**
Pearson Chi-Square	9.819[a]	6	.132	.123		
Likelihood Ratio	9.469	6	.149	.181		
Fisher-Freeman-Halton Exact Test	8.447			.151		
Linear-by-Linear Association	2.138[b]	1	.144	.157	.087	.026
No of Valid Cases	67					
a. 8 cells (66.7%) have an expected count less than 5. The minimum expected count is .60.						
b. The standardized statistic is -1.462.						

The findings from this study also indicate that the frequency of usage also varies by the level of education. A large proportion of users with a high school diploma (41%) use their device constantly and a smaller proportion of users with a bachelor's degree (22%) and a master's degree (30%) use their wearable constantly. Similarly, users with a high school diploma (36%) and a bachelor's degree (36%) use their device more frequently than other users with different levels of education (see Table 18).

Table 18

Crosstabulation of wearable device usage by the level of education

FREQUENCY OF USAGE (Prolong used)		**Level of Education**						**Total**
		High School	**Trade School/ Vocational School**	**Bachelor's degree / Interim Diploma**	**Master's degree / Diploma State Exam**	**PhD or higher**	**Others**	
Never	Count	2	0	3	2	0	1	8
	Expected Count	2.9	.6	2.1	2.1	.1	.1	8.0
	% Within	25.0%	0.0%	37.5%	25.0%	0.0%	12.5%	100%
Sometimes	Count	2	1	2	2	1	0	8
	Expected Count	2.9	.6	2.1	2.1	.1	.1	8.0
	% Within	25.0%	12.5%	25.0%	25.0%	12.5%	0.0%	100%
Often	Count	5	1	5	3	0	0	14
	Expected Count	5.0	1.0	3.8	3.8	.2	.2	14.0
	% Within	35.7%	7.1%	35.7%	21.4%	0.0%	0.0%	100.0%
Always	Count	15	3	8	11	0	0	37
	Expected Count	13.3	2.8	9.9	9.9	.6	.6	37.0%
	% Within	40.5%	8.1%	21.6%	29.7%	0.0%	0.0%	100%

TEST OF HYPOTHESIS

$\boldsymbol{H_0}$: Frequency of usage is independent of the level of education

Vs

$\boldsymbol{H_1}$: Frequency of usage is dependent on the level of education

DECISION RULE: reject H_0 if p-value$\leq \alpha$, otherwise do not accept H_0 (sig. level = .05)

A Chi-square test of independence between frequency of usage and level of education revealed no statistically significant relationship, X^2 (15, N=67) = 17.816, p=.272. Similarly, Fisher's exact test revealed that there was no statistically significant relationship between frequency of usage and level of education (p=.620). We may conclude that frequency of usage is independent of the level of education, we therefore accept our null hypothesis (see Table 19).

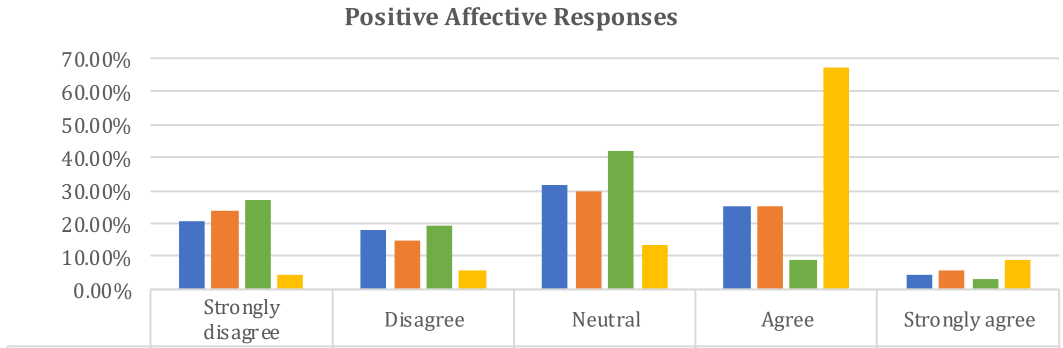
Table 19

Chi-square test of independence by the level of education

Chi-Square Tests						
	Value	**df**	**Asymptotic Significance (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**	**Point Probability**
Pearson Chi-Square	17.816[a]	15	.272	.299		
Likelihood Ratio	12.130	15	.669	.703		
Fisher-Freeman-Halton Exact Test	13.521			.620		
Linear-by-Linear Association	2.206[b]	1	.137	.143	.076	.012
No of Valid Cases	67					
a. 20 cells (83.3%) have an expected count less than 5. The minimum expected count is .12.						
b. The standardized statistic is -1.485.						

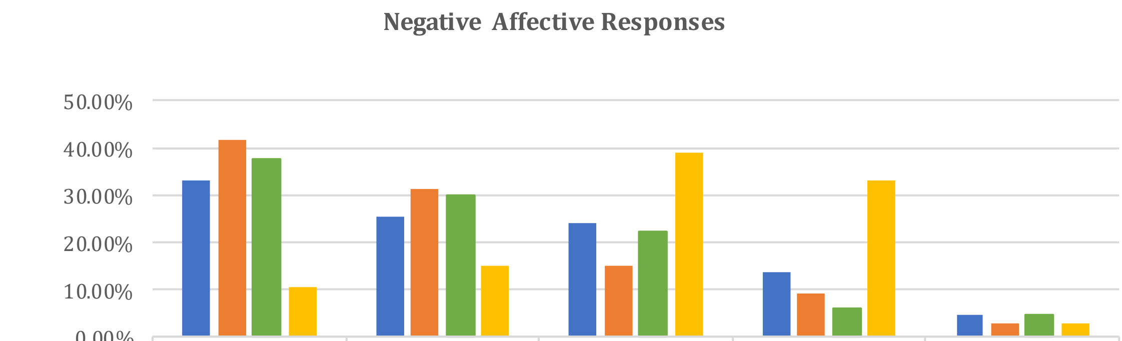
4.6 User's Psychological Response to Wearable Device Usage

According to the current study, the majority of users agree that they feel more motivated (67.16 %), empowered (8.96 %), cool and accountable (25.37 %) when they use their wearable device, while 41.79 % of users have a neutral feeling about being empowered, 29.85 % have a neutral feeling about being accountable, 31.34% have a neutral feeling about feeling cool and 13.43% have a neutral feeling about feeling motivated (see Figure 10). Similarly, 32.84% of users strongly disagree that they are anxious, 41.79% strongly disagree that they are guilty, 37.31% strongly disagree that they are frustrated and 10.45% strongly disagree that they are unmotivated when they are unable to use their wearable device, with 38.81% neutral and 32.84% agreeing to feel unmotivated when they are unable to use their wearable devices (see Figure 11). The findings indicate that using a wearable is a positive experience with little risk of negative psychological effects.



	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Cool	20.90%	17.91%	31.34%	25.37%	4.48%
Accountable	23.88%	14.93%	29.85%	25.37%	5.97%
Empowered	26.87%	19.40%	41.79%	8.96%	2.99%
Motivated	4.48%	5.97%	13.43%	67.16%	8.96%

Figure 10. Affective responses in users when they use their wearable device.



	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Anxious	32.84%	25.37%	23.88%	13.43%	4.48%
Guilty	41.79%	31.34%	14.93%	8.96%	2.99%
Frustrated	37.31%	29.85%	22.39%	5.97%	4.48%
Unmotivated	10.45%	14.93%	38.81%	32.84%	2.99%

Figure 11. Affective responses in users when they are unable to use their wearables.

4.7 Non-Users' Perceptions of Wearable Devices and Lifestyle Changes

This section presents data on non-users general opinions of wearable devices, including perceptions of wearable devices as a tool to influence physical activity participation and other lifestyle variables and factors they feel can contribute to the adoption of wearable devices. The difference in physical activity levels and changes in lifestyle or behaviour between users and non-users were also analyzed to further investigate the efficacy of wearable device usage on physical activity and other lifestyle factors.

4.7.1 Non-users perceptions of wearable device

In this study, 46.3% of non-users were uninterested in using a wearable device, 15% do not see a clear benefit to what the device can do for them while some believe it is unnecessary because their smartphone functions similarly to a wearable device. Similarly, 22.4% of non-users believe the device is overpriced, others doubt the data generated by this device and others are concerned about data privacy (see Figure 12).

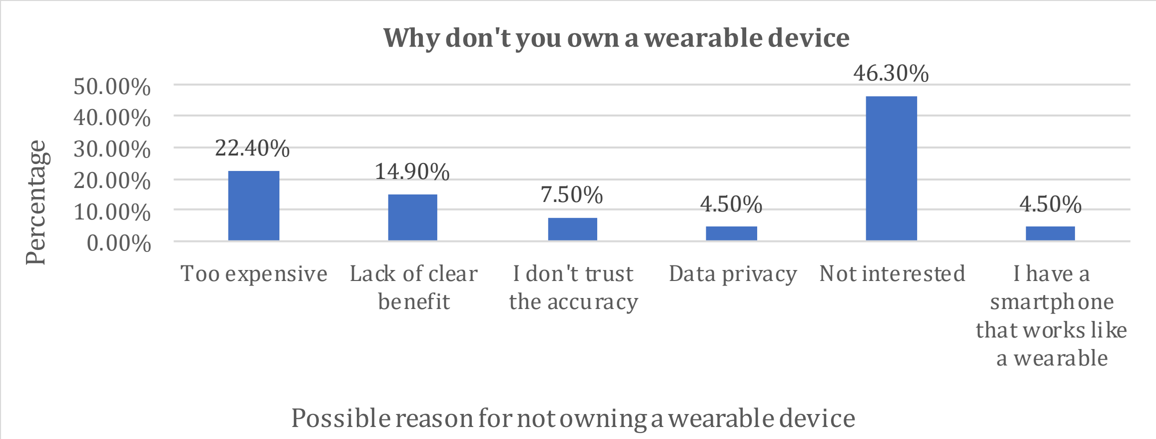
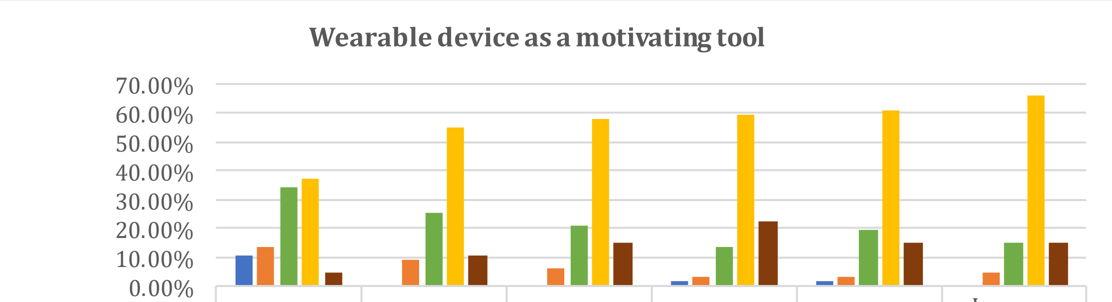


Figure 12. Reasons why non-users don't own a wearable device.



	Improve appearance	For weight loss	Improve health	Monitor activities	Improve fitness	Improve physical activities
Strongly disagree	10.40%	0.00%	0.00%	1.50%	1.50%	0.00%
Disagree	13.40%	9.00%	6.00%	3.00%	3.00%	4.50%
Neutral	34.30%	25.40%	20.90%	13.40%	19.40%	14.90%
Agree	37.30%	55.20%	58.20%	59.70%	61.20%	65.70%
Strongly agree	4.50%	10.40%	14.90%	22.40%	14.90%	14.90%

Figure 13. Non-users perceptions of wearable devices as a motivating tool.

Non-users were also polled on their opinions on wearable devices as a motivating tool for improving one's lifestyle and behaviour. Non-users in this study agree more than disagree that a wearable device can be a motivating tool for improving one's appearance (37.3%), weight loss (55.2%), improve health (58.2%), monitoring activities (59.7%), improve fitness (61.2%) and physical activities (65.7%) (see Figure 13).

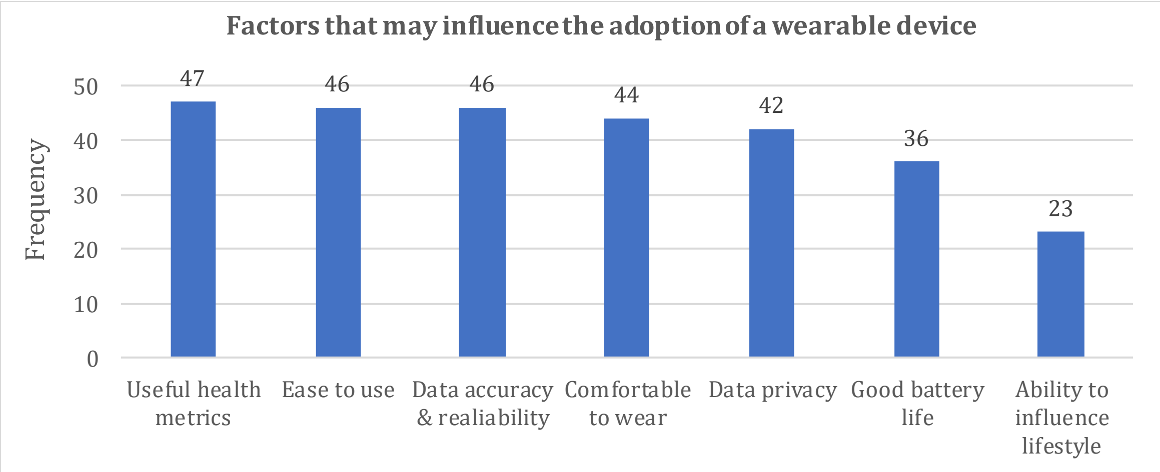


Figure 14. Non-users perceptions of factors that can influence the adoption of a WDs.

The findings of this study show that meaningful health metrics, design, data accuracy and reliability, comfort to wear and data privacy are important issues for non-users in wearable device adoption, while battery life and the device's ability to influence lifestyles are the least important considerations for wearable device adoption (see Figure 14).

4.7.2 The difference in lifestyle changes between users and non-users

Figures 15 and 16 depict the degree to which users and non-users believe wearable devices can influence their lifestyle and the disparities in physical activity levels between users and non-users to further assess the efficacy of wearable devices on physical activity, while Figures 17 and 18 present differences in users and non-users lifestyle and change in behaviour in the last 12 month.

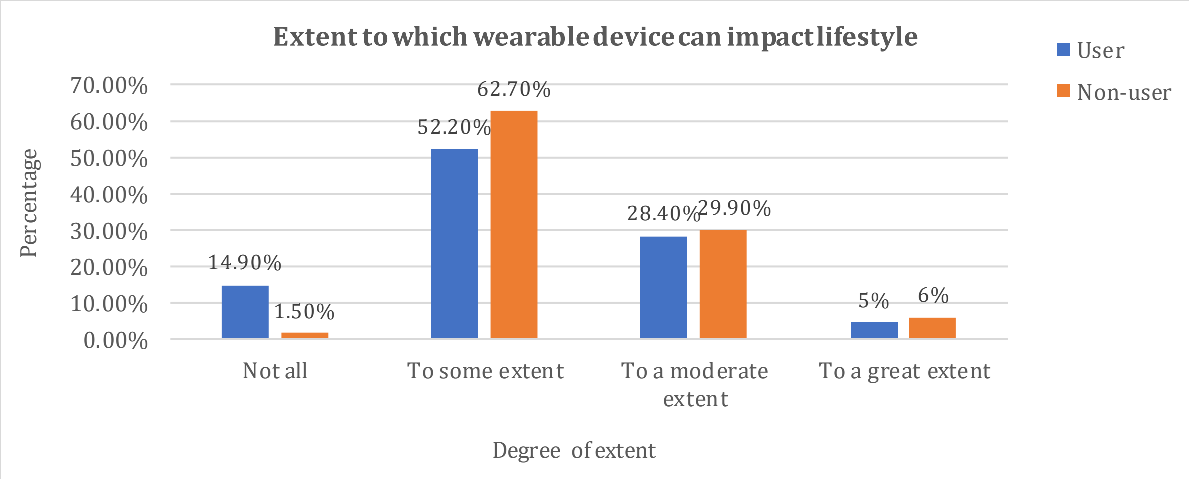


Figure 15. The degree to which users & non-users believes wearable device can influence their lifestyle.

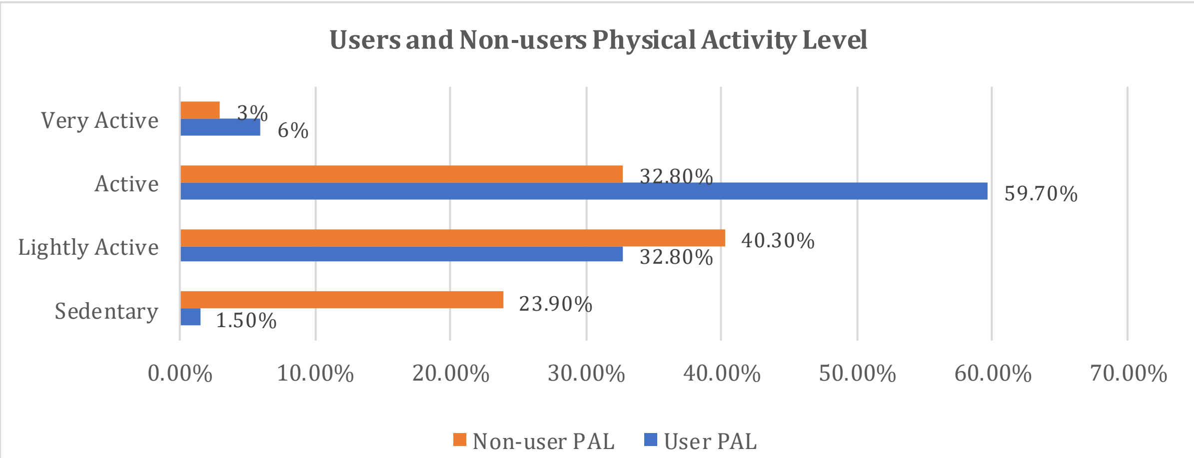


Figure 16. The difference in users' and non-user physical activity levels.

Both users (SE 52.2%; ME 28.4%) and non-users (SE 62.7%; ME 29.9%) feel that wearable devices may affect their lifestyle to some level or a moderate extent (Figure 15). Key findings from figure 16 show that wearable device users are more physically active (59.70%) than non-users (32.80%). At the same time, there is only a small difference between users and non-users who are lightly active, but of great concern is the percentage of non-users who are sedentary (23.90%) compared to wearable device users who are (1.5%).

The findings from Figures 17 and 18 show that wearable device users agree to have been more physically active (50.75%) than non-users (28.4%). Similarly, 44.78% of users agree to have incorporated healthily routines into their daily lives slightly more than non-users (35.82%). Furthermore, 37.31% of non-users agree to eat and drinking healthier than users (11.94%), while a considerable number of users and non-users are unsure whether they have managed their general health, stress level, or sleep better with or without wearable device usage in the last 12 months.

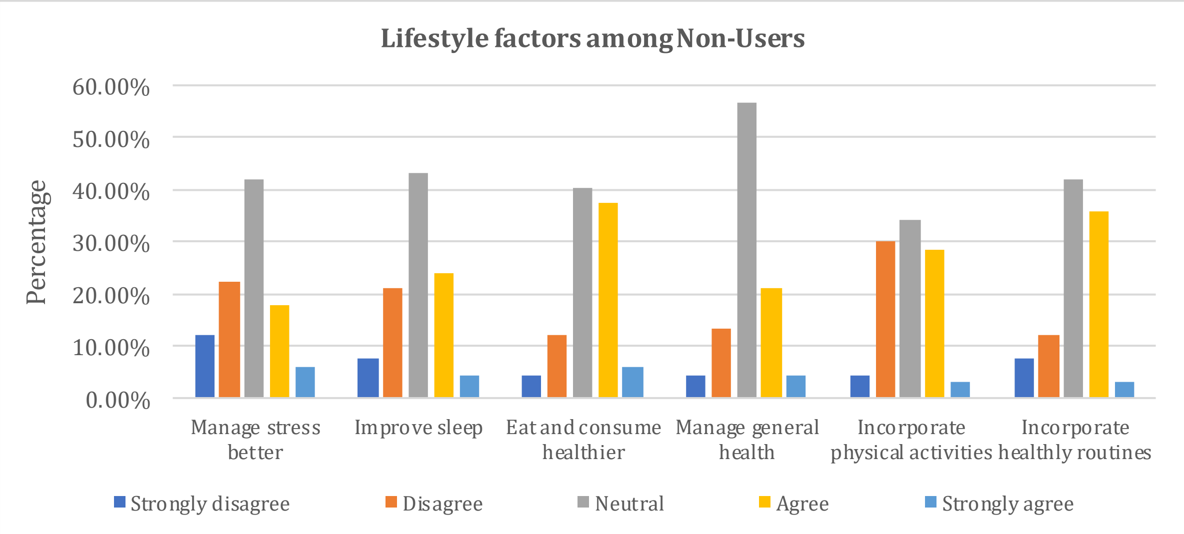


Figure 17. Changes in lifestyles factors among non-users in the last 12 months.

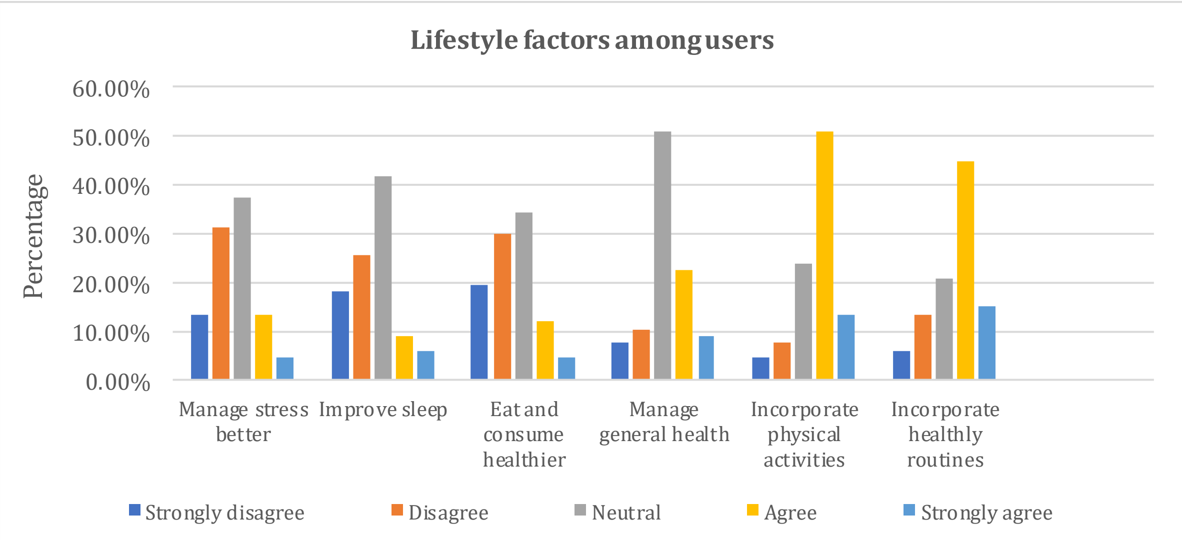


Figure 18. Changes in lifestyles factors among users in the last 12 months.

5. Discussion

The purpose of this thesis is to assess the impact of wearable devices on physical activities and lifestyle factors. It also investigates users' psychological reactions to the use of wearable devices, as well as non-users' perceptions of the impact of wearable devices on lifestyle changes. This study used a cross-sectional research design and a quantitative research method. The convenience sampling method was used, which included people who were the most accessible. As a result, Hamburg has been chosen as the study area and the target population is made up of Hamburg students and HAW University of Applied Sciences employees. Hamburg students and employees completed 134 of the 255 questionnaires. As a result, the final analysis included 134 questionnaires. Students make up a sizable proportion of the sample.

5.1 Users Experience and Perceptions of Wearable Devices

5.1.1 Wearable device frequency of use and usage pattern

The percentage of smartwatches users in this study is slightly higher than the percentage of fitness/activity tracker users (see Table 3), this is consistent with data reported by "Statista" (a market and consumer data company), which shows that smartwatches, head-mounted displays and ear-worn devices are the wearable technology market's fastest-growing products (Statista, 2021). The result shows that the use of wearable devices has increased (about 30% of wearable device users acquired their devices within the last year). The recent increase in the adoption of wearable devices can be associated with advancement in wearable devices technology, resulting in better, more accurate, precise self-tracking tools and appealing design. Other factors reported by GlobalData (2019) such as growing interest in health management, well-being, fitness, disease prevention and paradigms shifts toward personalized and individualized healthcare could also be contributing factors to the recent adoption of wearable devices. The observed high frequency of use among most users can be attributed to user intention and perception, because people are more likely to use an application or device if they believe its functions are valuable. Lee & Lee (2020) came to a similiar conclusion: when a wearable device is perceived as a useful technical tool, a person's use intention may lead to actual behavior. In the next section, we explore users' motivation and change in usage over time.

5.1.2 Wearable device usage intention and change in usage overtime

5.1.2.1 Motivation for using wearable devices

It is widely assumed that people use wearable devices to monitor some aspect of their lives and to improve their lifestyles, as people find real-time feedback from these devices motivating for self-monitoring, whereas others acquire their wearable devices simply to keep up with technology (Ridgers *et al*., 2016). The result from this study reveals that users' main motivation for using their wearable devices is to track their activities and improve their health and fitness. These findings reinforce the general assumption that wearable devices can assist people in monitoring their health status at the activity/fitness level for self-health tracking. Furthermore, the growing interest in fitness and personalized health management are making wearable devices a more popular tool for monitoring activities and improving people's overall health (Yoon et al., 2020). As the popularity of devices rises, it has the potential to keep users engaged and invested in their health, facilitating greater participation in physical activity, continuous monitoring of more metrics and promoting other healthier lifestyles for a better quality of life.

5.1.2.2 Goal setting

Beyond activities tracking, wearable devices are expected to provide more than simply objective tracking information; they may inspire users to be more active based on their subjective assessment of the statistics provided to them such as achieving a specific goal, receiving a reward and sharing their goal progress with their networks (Munson & Consolvo, 2012). Bailey Ryan defines goals as mental representations of desired outcomes and goal setting as the process of identifying specific goals and figuring out how to accomplish them. Health behaviour change is difficult for most people, goal setting has been recognized as one of the strategies for motivating a person to begin or sustain behavioural changes within an intervention (Bailey, 2017) and it is commonly incorporated in physical activity interventions (Greaves *et al*., 2011; Munson & Consolvo, 2012). Findings from this analysis revealed that a high proportion of wearable device users set daily targets for themselves. Collectively, users' daily goals are higher in activity monitoring than in other metrics such as calorie estimation, sleep and general health status. This may be due to the complexity of estimating calorie consumption, which in most cases requires manual input of food and water consumed. This method also applies to sleep and health metrics such as blood glucose. The convenience of automatically tracked physical activities such as steps and active time may be a strong motivator for goal setting in activities monitoring. Setting a goal for health behaviour change, on the other hand, is rarely enough to result in behaviour change. To change behaviour, one must follow through with one's intentions and remain committed to achieving the goal set. This leads us to investigate how users' commitment to their wearable devices changes over time.

5.1.2.3 Change in usage pattern over time

A fundamental design issue and critical question for the relevance of wearable activity trackers is whether and how they support behavioural changes in long-term use. Beyond the permanent figure on their wrists, how users engage with their devices daily was analyzed to see if frequency resulted in a stronger connection or dedication to their device. From the result, the number of users who use their devices regularly at the initial stage decreases after prolonged use, there was also a change in the frequency at which users checked feedback such as daily goals reached, active minutes, sleep analysis, etc., as recorded by their wearable tracker. Many users initially check the data collected by their wearable device, but this decreases over time. Although, the results show a decrease in most users' daily engagement with feedback data but does not indictate most users stopped using their wearables in a long term. This findings is supported by Fritz *et al.* (2014) who ascertained that while many people finally ended up with them, even after many months or years of use some continue to derive value and motivation. This suggests that decrease in user's engagement does not necessarily imply a failure in supporting behaviour change because users continued to wear their device, implying gradual and successful adoption. On the other hand, the results partially support the findings of McCarthy & Wright (2004) who discovered that while more than one-third of wearable activity tracker users rejected them within six months, in this study, only 6% completely rejected their wearable device after initial use. These findings raises the question of what factors may be influencing continuous use. The most common complaints users have about their wearables are; wear and tear, technical problems, low battery life, security & privacy, negative psychological effects, difficulty reading/interpreting data, inaccuracy when recording the data, boredom, exhaustion e.tc. These could also be contributing factors to decrease in feedback checking and wearable device usage. However, this study did not specifically look into the factors that cause users to stop using or checking feedback generated from their device; thus, causes of decline in the frequency of usage and feedback checking should be investigated further.

5.2 Physical Activity Level and Lifestyle Factors

Research Question 1: Does wearable device usage influence PA and other Lifestyle Factors?

5.2.1 Relationship between wearable device usage and lifestyle factors

The first objective of this study is to assess the efficacy of wearable device usage in terms of physical activity as well as other lifestyles factors such as diet, sleeping pattern, stress and overall health management. A crosstab table was created to analyze the association between the use of wearable devices and the extent to which users expected the item to alter their lifestyle. A Chi-square test of independence was also used to test for statistically significant relationship between lifestyle factors and wearable device usage. The result of users expectations and perceived impact of wearable devices on lifestyle factors are discussed below.

5.2.1.1 Users' expectations and perceived impact on physical activity level

Healthy lifestyle technologies like wearable devices or fitness trackers are suggested to provide new and exciting opportunities for physical activity promotion. The access to personalized data on behavioural activity, as well as the ability to track, compare, and monitor behaviour, is alleged to have a huge potential for influencing cognitions and emotions, as well as increasing physical activity levels (Kerner & Goodyear, 2017). The current findings from this study show that wearable devices can help users improve their physical activity level; however, this can also depend on users' level of expectation since users who expected wearable devices to impact their lives were able to incorporate more physical activities into their lifestyle compared to users without expectation. This is consistent with the findings reported by Brickwood *et al. (*2019) that wearables can promote physical activity, increase energy expenditure and minimize sedentary behaviour. This is also in line with the findings of Bice *et al*. (2016); Kerner & Goodyear

(2017) that wearable fitness trackers and their associated apps increase physical activity levels.

5.2.1.2 Users' expectations and perceived impact on other lifestyle factors

Eating a healthy, balanced diet, along with other lifestyle factors such as sleep pattern, stress level, general health, healthy routine etc. have the potential to significantly improve our health and quality of life, which is why self-monitoring of calorie intake, sleep, stress, general health management is becoming increasingly important. Although, ongoing research has identified wearable devices as a promising way to track food and nutrition intake, only a few are reliable for accurate and precise nutrition measurement (Dimitratos *et al*., 2020). This could explain why, in this study, users who had no expectations do not have a strong conviction that using a wearable device could help them with their nutrition. However, a sizable number of users who had high expectations for their wearable device agree that they have been eating and consuming healthier, indicating that wearable devices have the potential to help users monitor and improve their eating habits to an extent.

Wearable devices, sleep apps and online programs are popular methods of dealing with sleep challenges. Many people find these tools useful because the information and feedback provided by the device can help them track and monitor their sleep patterns, allowing them to focus on areas for improvement. The findings of this study show that a substantial number of users agree and strongly agree to have been sleeping better since they started using their wearable device. However, research on the reliability of wearable-based monitoring has revealed that these devices frequently overestimate total sleep time or underestimate total wake-up time (Guillodo *et al*., 2020). Lack of trust in wearable devices may explain why a high percentage of users with no expectation strongly disagree and disagree with the device helping them in improving their sleep patterns.

Stress monitoring is another recent advancement of wearable technology in the world of health and wellness. Everyday stress to chronic stress from work or lifestyle can have an impact on our health, which is why stress monitoring is important. Wearable device manufacturers have now included stress monitoring in their devices to improve overall mental and physical health, allowing people to dive deeper into their mental health management in addition to physical wellbeing. Wearable device monitoring of stress levels is still in its early stages (Ometov *et al*., 2021), which may also explain why many users in this study have low expectations for their wearable device to help them monitor and manage their stress levels better. However, few users who expected their wearable device to help them manage their stress level agree that they were able to do so to an extent. One method used by wearable devices such as the Apple Watch, Samsung Galaxy Watch and Fitbit trackers to monitor stress levels is heart rate variability (the measurement of the time interval between heartbeats). Although lower heart rate variability is frequently linked to stress, this measurement is insufficient to determine whether or not a person is stressed (Samson & Koh, 2020). Nevertheless, a wearable device with a stress monitoring feature can assist a person in better understanding one's stress levels, what triggers them, and developing a plan to reduce stressors or learn how to manage them more effectively over time.

Another fascinating finding about Wearable Health Devices (WHDs) is that they can enable continuous outpatient monitoring of human vital signs while at work, at home, during sports activities and so on, with the advantage of minimizing discomfort with human activities. Heart rate, blood pressure, blood glucose, respiratory rate, blood oxygen saturation and body temperature are some vital signs that have become routine measurements in both healthcare and fitness activities (Dias & Paulo Silva Cunha, 2018). Self-monitoring of these vital signs can reduce the risk of disease development while also providing more data to individuals and clinicians, potentially leading to earlier diagnosis and treatment guidance for improved quality of life. In this study, a considerable number of users with high expectations agree to wearable devices assisting them in managing their overall health, whereas a significant number of users with low to moderate expectations are neutral about wearable devices assisting them in managing their overall health. As a result of this finding, we can conclude that many people have not yet been using wearable devices to monitor vital signs. We speculate that this could be due to several factors such as the availability of such metrics on their device, data reliability, data accuracy and so on. In addition, wearables differ in the metrics they measure, basic wearable devices typically have fewer functions and metrics than advanced wearable health devices, which are more expensive.

5.2.1.3 Test of independence between lifestyle factors and wearable device usage

The result of the Chi-square test (see Table 13) indicates the violation of one of the assumptions for chi-square independence (i.e., for a larger table than 2 x 2, no more than 20% of all cells should have an expected count < 5). As a result of this limitation, Fisher's exact test was also computed to reduce the risk of making a wrong decision (Cochran, 1952; Kroonenberg & Verbeek, 2018). The result of the Chi-square test of independence and Fisher exact test found no statistically significant relationship between wearable device usage and eating habits, sleeping patterns or stress management. We may conclude that lifestyles factors including eating habits, sleeping patterns, stress management are independent of usage. On the other hand, a Chi-square test of independence between wearable device usage time and physical activity, overall health management and incorporating healthy routines into everyday lives, revealed a statistically significant relationship. We may conclude that adopting healthy behaviours, managing overall health and incorporating more physical activity into daily life all depend on usage length. The findings in the study have suggested a substantial number of users who expected wearable devices to greatly influence their lifestyle have been able to incorporate more healthy routines into their everyday life.

Research Question 2: How do socio-demographic characteristics influence wearables device usage patterns?

5.2.2 Relationship between wearable device usage and socio-demographic

The second objective of this research is to explore socio-demographic characteristics that influence wearable device usage. The Chi-square test of independence and Fisher's test were performed to examine whether there is a statistically significant association between socio-demographic characteristics and frequency of usage following a period of protracted use. Female users in this study had a higher frequency of usage after a long period of time than male users. The crosstabulation of wearable devices by age shows that the frequency of usage varies significantly by age group, however, users between the ages of 18 and 39 have a higher frequency of usage after a long period of time than users aged 40 and above (see Table 16). This could be because young people are increasingly turning to technology for health information and are drawn to the design and visual appeal of wearable devices. Elderly people may find wearables to be more intrusive, too complicated and uncomfortable. The findings from this study also indicate that the frequency of usage also varies dramatically by the level of education. A high number of users with a high school diploma, a bachelor's degree and a master's degree use their wearable more frequently, always and occasionally than other users with different levels of education (see Table 18). In keeping with the study's goal of investigating socio-demographic variables that impact wearable activity tracker usage, the data show no statistically significant relationship between frequency of usage and gender, age groups, or level of education. The generalizability of these findings is restricted by the three socio-demographic factors included in the research; there may be no conclusive conclusions about whether the frequency of usage is affected by additional socio-demographic characteristics.

5.3 Affective Responses

Research Question 3: How do user's affective responses differ when they can use their devices and when they do not use them?

5.3.1 User's psychological response to wearable device usage

The third objective of this study is to examine users' affective responses to their wearable devices. The level of impact felt when using wearable technology and thereafter can influence user behaviour in the future. As a result, it is essential to evaluate how wearable devices impact users' emotional states when they are wearing them and when they are not, as this may influence usage, their possibility of continued use, and their overall psychosocial well-being. To measure consumers' emotional responses to their wearables, an 8-item scale similar to existing instruments (positive and negative affect scale) by Ryan *et al*. (2019) was devised. Participants were asked to indicate the amount to which they agreed that they had experienced a certain emotional state or feeling during a given time frame, with responses assessed on a 5-point Likert scale. There were four items asking participants to state to what extent "when I use my wearable I am feeling [cool, accountable, empowered, motivated] and four items that asked the participants to say to what extent "I feel [anxious, guilty, frustrated, unmotivated] if I am not using/forget/can't wearable." The current findings from this study show that users had a positive experience with their wearables and wearable devices provide users with positive psychological benefits such as increased motivation, empowerment, and accountability while posing little risk of negative psychological consequences such as users feeling unmotivated when they are unable to use their device (see Figures 10 and 11). This is consistent with the findings reported by Karapanos *et al*. (2016) who found that using a wearable device is a positive experience for users as the device provides users with several psychological advantages and few negative psychological consequences. Etkin (2016), on the other hand, reported that activity tracking may have a negative impact on users' psychological well-being, such as decreasing the enjoyment associated with walking-based physical activity, which can discourage users from using it in the long run. A variety of factors influence the continued use of wearable devices such as the perceived future value of data recorded, engagement and empowerment etc. The positive psychological response that users derived due to the use of wearable devices can contribute to the prolonged usage of their devices.

5.4 Non-Users' Perceptions of Wearable Devices, PAL and Lifestyles

Research Question 4: What are the non-users perceptions of wearable devices as tools for influencing lifestyle and overall health?

5.4.1 Non-users perceptions of wearable device

The fourth objective of this study is to explore non-users perceptions of wearable devices on lifestyles changes. Although wearable technologies are exciting advancements, their acceptance has lagged behind compared to other well-established, durable technological items, including smartphones and tablets (Cheung et al., 2019). There are numerous reasons why people choose to use a device or do not use one. In this study, a large number of non-users were uninterested in using a wearable device because some do not see a clear benefit to what the device can do for them, while others believe it is unnecessary because their smartphone functions similarly to a wearable device. Similarly, some non-users believe the device is overpriced, others doubt the data generated by this device, and others are concerned about data privacy (see Figure 12). Non-users were also asked about their thoughts on wearable devices as a motivating tool for improving one's lifestyle and behaviour. In line with previous research, non-users in this study agree more than disagree that a wearable device can be a motivating tool for improving one's appearance, health, fitness, physical activities and for weight reduction (see Figure 13). Regardless of the potential benefits and applications of wearable devices, some limitations slowing the adoption of WDs identified in this study are meaningful health metrics, design, data accuracy and reliability, comfort to wear and data privacy are key issues which is consistent with the findings of Perez & Zeadally (2018); Chandrasekaran *et al.* (2020); Chuah *et al.* (2016), that design, data accuracy and reliability of wearables are significant issues for non-users. Battery life and the device's ability to influence lifestyles are the least important considerations for wearable device adoption (see Figure 14).

5.4.2 The difference in lifestyle changes between users and non-users

According to prior research by Chandrasekaran *et al.* (2020), wearable devices have several potential benefits for users, ranging from real-time health information sharing to providing feedback to users for them to make appropriate changes to their daily routines and to remote patient monitoring to improve health care delivery, among other things. However, it is still unclear whether the behaviour change techniques included in wearable technology such as fitness/activity trackers are sufficient for changing behaviours over time. According to this study's findings, there is high support for the use of wearable devices as a tool to promote physical activity. Both users and non-users feel that wearable devices may affect their lifestyle to some level or a moderate extent (Figure 15). The key findings show that wearable device users are more physically active than non-users, however, there is only a small difference between users and non-users who are lightly active. The percentage of non-users who are sedentary is of great concern when compared to wearable device users who are. The findings also show that wearable device users are slightly more physically active and have incorporated healthily routines into their daily lives than non-users. Furthermore, a sizable number of users and non-users are unsure whether they have improved their general health, stress level, or sleep in the last 12 months with or without the use of a wearable device.

Most health-related behaviours, such as eating well, staying active and incorporating healthy routines etc can only lead to meaningful improvements in population health if they are sustained. Using wearable devices to effectively promote health behaviour change is a multistep process; thus, wearable devices are more beneficial when combined with other behavioural strategies.

6 Conclusions and Recommendation

6.1 Conclusion

This study provides insights on the impact of wearable devices on physical activity and other lifestyle factors, what might influence usage and acceptability, as well as non-users' perceptions of wearable devices. The study also provides data on users' emotional responses, or how wearable devices influence users psychologically. It provides insights into a subject that is currently understudied by researchers and serves as a foundation for future research. One of the most important reasons consumers opt to use a wearable device is to track activities to enhance health and fitness. While activity trackers may collect data on a wide range of activities (including physical activity, diet, and sleep), physical activity emerged as the most often tracked activity. Surprisingly, step counting was the most popular of the several physical activity measures offered. Furthermore, a large group of users uses their device daily, as opposed to few days in a week or while exercising. Goal setting is one of the strategies for encouraging a person to initiate and sustain behavioural changes in physical activity interventions, a large number of users in this study established daily goals for themselves. Users' usage intention may influence users' commitment to their device in a long term. Although the frequency of usage and feedback may diminish over time, users continued to use their devices. There is no sufficient evidence established that frequent usage and data comparisons motivate users to use the device more regularly or contribute to users feeling bored and exhausted in the long term.

This study adds to a growing body of research demonstrating the effectiveness of wearable devices as an intervention in promoting physical activity and decreasing sedentary behaviour, as the number of users who were sedentary before using their wearable device decreased after they began using their wearable device. Analysis from this study also reveals that adopting healthy behaviours, managing overall health, and incorporating more physical activity into daily life depends on usage length, implying that a longer usage time is required to have a greater impact on users' adoption of healthy behaviours, overall health management and physical activity engagement. A Chi-square test of independence indicated a statistically significant relationship between wearable device usage and adopting healthy behaviours or routines into everyday life. Furthermore, there is no statistically significant relationship between frequency of usage and gender, age groups, or level of education, implying that frequency of usage is independent of these three socio-demographic factors; however, the generalizability of these findings is limited by the three socio-demographic factors included in the research. In addition to the outcomes of this study, wearable activity trackers can provide users with positive psychological advantages such as improved motivation, empowerment and accountability. Wearables have a minimal risk of negative psychological effects; however, this risk appears to be users feeling unmotivated when they are unable to use their wearable devices. The key findings from disparities in physical activity levels of users and non-users show that wearable device users are more physically active than non-users, but the percentage of non-users who are sedentary when compared to wearable device users is of great concern. The major factors for the adoption of wearable devices from non-users were significant health metrics, design, comfortability, data privacy, data accuracy and reliability.

Finally, wearable technology has sparked a lot of interest in empirical research, partly because it is unclear whether these new devices will have a positive or negative impact on our lives, or even if they will have any impact at all. According to the study's findings, a significant number of users who expected wearable devices to significantly influence their lifestyle have been able to incorporate more healthy routines into their daily lives. Wearable devices can have a significant impact on users' lifestyles to varying degrees, depending on user expectations and length of usage. Their personal health-related goals or motivation for using a wearable device also have an impact on the extent of the impact. Individual intention and motivation, goal setting, social support, effective feedback and other factors, when combined with engagement strategies, are important factors that can effectively help promote health behaviour change over time. Wearable technology can help individuals and communities get healthy while also reducing pressure on the healthcare system by encouraging greater participation in physical activity and promoting other healthy lifestyles.

6.2 Study Limitations and Future Research Direction

Despite the useful findings of wearable device as a potential intervention tool for healthy lifestyles in this study, some limitation persists, suggesting directions for future research. The present study's participants include students and a few employees at a HAW (Hamburg University of Applied Sciences). The current study's mean age is 28.05 years (SD = 7.68 years), which reflects the overall age of university students, however, because young individuals are generally more open to new technologies, this may have impacted the results. Because of these, it is suggested that future studies focus on a more varied sample of people. Furthermore, due to the survey's small sample size, it is difficult to make firm conclusions about any of the findings. A larger sample size with a longer follow-up period (at least 1 year) across varied contexts is required to enhance the generalizability of the findings. The concept of 'goals,' as well as 'users' reactions to creating and fulfilling them, might be revisited. If 'goals' are specified by numbers shown on the device, it may be possible to clarify the relationship between what data represent improved behaviour. It might also attempt to determine whether the efficacy of achieving this 'objective' is a short-term or long-term change. Further research on this subject might clarify factors that influence lack of motivation and drop-off rate after prolonged usage. As a result, causes for discontinued use, such as boredom, wear and tear, technological difficulties, security & privacy etc should be investigated further, along with further information on how to optimize wearable devices usage in the future. While there are some interesting findings in this study to suggest these devices may have the potential to increase activity levels through self-monitoring and goal setting in the short term, more research is needed to ascertained longer-term effects on behaviour. Therefore, it is imperative to examine post-adoption attitudes such as users' intentions. Further investigation of these themes could strengthen knowledge around the effectiveness of the wearable device in the promotion of physical activity and other lifestyle factors.

7 References

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8 Appendix

Appendix I: The Questionnaire

Impact Evaluation of Wearable Devices in Promoting Physical Activity and Healthy Lifestyle for Better Quality of Life

This survey is part of a research project on applications of wearable devices in promoting physical activity and healthy lifestyle. Please note: You must be 18 years of age or older to participate in this study. By completing this survey, you are consenting to participate in this study.

This survey takes approximately 10-15 minutes to complete. Your data will be protected as it is completely anonymously and will be used for academic purposes only. If you have questions about the study or the procedure, you may contact the researcher via email at [Opeyemi.Ayanwale@haw-hamburg.de]

Thank you for considering taking part in this survey!

There are 42 questions in this survey.

Section A: Personal Information

1. **Please select the German State you reside in.**

*(If you reside outside Germany please choose ''other'' and state your country of residence).**

Please choose **only one** of the following

- ◯ Bavaria Lower
- ◯ Saxony
- ◯ Baden-Württemberg
- ◯ North Rhine-Westphalia
- ◯ Brandenburg
- ◯ Mecklenburg-Vorpommern
- ◯ Hesse
- ◯ Saxony-Anhalt
- ◯ Rhineland-Palatinate
- ◯ Saxony
- ◯ Thuringia
- ◯ Schleswig-Holstein
- ◯ Saarland
- ◯ Berlin
- ◯ Hamburg
- ◯ Bremen
- ◯ Other ________

2. What is your gender? *

Please choose **only one** of the following:

◯ Female ◯ Male ◯ Diver ◯ Prefer not to say

3. How old are you? *

Your answer must be at least 18

Please write your answer here:

4. What is the highest level of education you have completed? *

Please choose **only one** of the following:

- ◯ High school
- ◯ Trade school / Vocational school
- ◯ Bachelor's degree / Interim Diploma (or equivalent)
- ◯ Master’s degree / Diploma / State examination (or equivalent)
- ◯ PhD or higher
- ◯ Other ________

5. In which occupational group are you currently working? (If you are conducting several occupations, please refer to your primary occupation). *

Please choose **only one** of the following:

- ◯ Managers (e.g. chief executives, administrative managers)
- ◯ Professionals (e.g. science, engineering, health, and teaching professionals)
- ◯ Technicians and associate professionals (e.g. science, engineering, associate...)
- ◯ Clerical support workers
- ◯ Service and sales workers
- ◯ Skilled agricultural, forestry and fishery workers
- ◯ Craft and related trades workers
- ◯ Plant and machine operators, and assemblers
- ◯ Elementary occupations (e.g. cleaners and helpers, labourers in mining)
- ◯ Housewife/Househusband
- ◯ Armed forces occupation
- ◯ I am a student
- ◯ Retired
- ◯ I am not employed at the moment
- ◯ Other ________

Section B: Users experience and perceptions of wearable devices

These are general questions about wearables and your experience using wearables. If you have more than one wearable, please answer the questions based on the one you use most frequently.

A wearable device is a technology that is worn on the human body and is often used for tracking a user's vital signs or pieces of data related to health and fitness, location or even his/her biofeedback indicating emotions.

6. Do you use a wearable device e.g. pedometer, calorie meter, heart rate and sleep monitor, etc.? *

Please choose **only one** of the following:

- ◯ No, never
- ◯ No, but I used to have one
- ◯ Yes, I'm currently using a wearable

7. What type of wearable do you / have used? *

Only answer this question if the following conditions are met:
Answer was 'Yes, I'm currently using a wearable' *or* 'No, but I used to have one' at question '6 [B6]' (Do you use a wearable device e.g. pedometer, calorie meter, heart rate and sleep monitor, etc.?)

Please choose **all** that apply:

- ☐ Fitness Tracker/Activity Tracker
- ☐ Smartwatch
- ☐ Intelligent/Smart Clothing
- ☐ Other: ____________

8. How did you get your wearable? *

Please choose **only one** of the following:

○ I bought it myself ○ A Gift ○ Provided by health insurer ○ Provided by

9. How long (in months) have you been using/used wearable? *

Please write your answer here: ____________

10. How often do you use your wearable device? *

Please choose **only one** of the following:

- ○ Once a year
- ○ Once a month
- ○ Once a week
- ○ Few days a week
- ○ Everyday
- ○ Only when I'm training

i. EXPECTATION PHASE (The following questions are intended to collect information on user's expectation & motivation to use wearable).

11. What is your main motivation for using wearable?*

Please choose **only one** of the following:

- ○ To improve appearance
- ○ To improve fitness
- ○ To improve health
- ○ For weight loss
- ○ To monitor activities
- ○ To keep up with new technology
- ○ Other ____________

12. Which other options motivate you to use wearable? *

Please choose **all** that apply:

- ☐ To improve appearance
- ☐ To improve fitness
- ☐ To improve health
- ☐ For weight loss
- ☐ To monitor activities
- ☐ To keep up with new technology
- ☐ Other: ____________

13. Do you have a daily goal? *

Please choose **only one** of the following:

- ◯ No
- ◯ Yes, sometimes
- ◯ Yes, always

14. If Yes: Please specify your daily goals *

Only answer this question if the following conditions are met:

Answer was 'Yes, I'm currently using a wearable' *or* 'No, but I used to have one' at question '6 [B6]' (Do you use a wearable device e.g., pedometer, calorie meter, heart rate and sleep monitor, etc.?) *and* Answer was 'Yes, always' *or* 'Yes, sometimes' at question '13 [B13]' (Do you have a daily goal?)

Please choose **all** that apply:

- ☐ Activity: Distance & Time
- ☐ Steps: Walk & Run
- ☐ Sleep: Record & Analyze
- ☐ Calories burned
- ☐ Calorie's consumption(food & water)
- ☐ Multi-Sport: Running+ Swimming + Cycling+ Cross Training
- ☐ General health status: Stress level + Heart rate + Blood glucose + Blood pressure + Saturation level
- ☐ Other: ____________

ii. INITIAL USE (The following questions are intended to collect information on a user's experience during first

weeks of use).

15. In the first weeks of use, how often did you wear the wearable device?*

Only answer this question if the following conditions are met:

Answer was 'Yes, I'm currently using a wearable' *or* 'No, but I used to have one' at question '6 [B6]' (Do you use a wearable device e.g. pedometer, calorie meter, heart rate and sleep monitor, etc.?)

Please choose **only one** of the following:

◯ Never ◯ Sometimes ◯ Often ◯ Always

16. In the first weeks of use, how often did you look at/reflect upon the collected information? *

Please choose **only one** of the following

◯ Never ◯ Sometimes ◯ Often ◯ Always

iii. PROLONG USED (The following questions are intended to collect information on a user's experience after a prolonged use).

17. Currently, how often do you wear the wearable device? *

Only answer this question if the following conditions are met:
Answer was 'Yes, I'm currently using a wearable' *or* 'No, but I used to have one' at question '6 [B6]' (Do you use a wearable device e.g. pedometer, calorie meter, heart rate and sleep monitor, etc.?)

Please choose **only one** of the following:

◯ Never ◯ Sometimes ◯ Often ◯ Always

18. Currently, how often do you look at/reflect upon the collected information from your wearable? *

Please choose **only one** of the following:

◯ Never ◯ Sometimes ◯ Often ◯ Always

Section C: Physical Activities and Lifestyles Factors

Physical activity is defined as any body movement that involves energy expenditure generated by skeletal muscles, including activities carried out while working, playing, performing household chores, traveling and participating in recreational activities.

19. Do you think your physical activities level changed since using wearable devices? *

Only answer this question if the following conditions are met:
Answer was 'Yes, I'm currently using a wearable' *or* 'No, but I used to have one' at question '6 [B6]' (Do you use a wearable device e.g., pedometer, calorie meter, heart rate and sleep monitor, etc.?)

Please choose **only one** of the following:

◯ No ◯ Maybe ◯ Yes

20. Before you got your wearable device, which physical activity level category do you consider yourself? *

Please choose **only one** of the following:

◯ Sedentary (No moderate or vigorous activities / less than 30 minutes of intentional exercise or activities per day)

◯ Lightly Active (Daily exercise that is equal to walking for 30 minutes / 15 - 20 minutes of vigorous activity on daily basis)

◯ Active (Daily exercise that is equal to walking for 1 hour and 45 minutes / 50 minutes of intense exercise per day)

◯ Very Active (Daily exercise that is equal to walking for 4 hours and 15 minutes / 2 hours intense exercise per day)

21. After getting your wearable device, which physical activity level category do you consider yourself? *

Please choose **only one** of the following:

◯ Sedentary (No moderate or vigorous activities / less than 30 minutes of intentional exercise or activities per day)

◯ Lightly Active (Daily exercise that is equal to walking for 30 minutes / 15 - 20 minutes of vigorous activity on daily basis)

◯ Active (Daily exercise that is equal to walking for 1 hour and 45 minutes / 50 minutes of intense exercise per day)

◯ Very Active (Daily exercise that is equal to walking for 4 hours and 15 minutes / 2 hours intense exercise per day)

22. To what extent did you expect your wearable to impact your lifestyle? *

Please choose **only one** of the following:

◯ Not at all

◯ To some extent

◯ To a moderate extent

◯ To a great extent

23. How much do you agree/disagree with the following statements? Since using my wearable I... *

Please choose the appropriate response for each item:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Incorporate more physical activities in my everyday life	◯	◯	◯	◯	◯
Eat and consume healthier	◯	◯	◯	◯	◯
Sleep better	◯	◯	◯	◯	◯
Manage stress level better	◯	◯	◯	◯	◯
Manage general health status	◯	◯	◯	◯	◯
Incorporate healthy routines into my everday life	◯	◯	◯	◯	◯

Section D: Effect of wearable

The following questions are intended to collect information on the effect of wearable devices on the psychological wellbeing of the users.

24. How much do you agree/disagree with the following statements? Since using my wearable it makes me feel... *

Please choose the appropriate response for each item:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Cool	◯	◯	◯	◯	◯
Accountable	◯	◯	◯	◯	◯
Empowered	◯	◯	◯	◯	◯
Motivated	◯	◯	◯	◯	◯

25. How much do you agree/disagree with the following statements? When i don't use/forgot/couldn't use my wearable it makes me feel... *

Please choose the appropriate response for each item:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Anxious	◯	◯	◯	◯	◯
Guilty	◯	◯	◯	◯	◯
Frustrated	◯	◯	◯	◯	◯
Unmotivated	◯	◯	◯	◯	◯

26. Do you have any complaints with your wearable? *

Please choose the appropriate response for each item:

	Never	Rarely	Sometimes	Often	Very often
Technical Problem	◯	◯	◯	◯	◯
It is uncomfortable to wear next to the skin	◯	◯	◯	◯	◯
Low battery life	◯	◯	◯	◯	◯
Inaccurate when recording data	◯	◯	◯	◯	◯
Problems reading/interpreting the data	◯	◯	◯	◯	◯
Experiencing negative psychological effects	◯	◯	◯	◯	◯
Safety, Security and Privacy	◯	◯	◯	◯	◯

27. Do you plan to continue using your wearable? *

Please choose **only one** of the following:

No ◯ Not sure ◯ Yes ◯

28. Overall, I have had a positive experience using my wearable. *

Please choose **only one** of the following:

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly agree

Section E: Non-users' perceptions of wearable devices

These are general questions about your perception about wearable devices.

A wearable device is a technology that is worn on the human body and is often used for tracking a user's vital signs or pieces of data related to health and fitness, location or even his/her biofeedback indicating emotions.

29. If you do not own a wearable, why is that? *

Only answer this question if the following conditions are met:
Answer was 'No, never' at question '6 [B6]' (Do you use a wearable device e.g. pedometer, calorie meter, heart rate and sleep monitor, etc.?)

Please choose **only one** of the following:

- ◯ Too expensive
- ◯ Lack of clear benefit
- ◯ I don't trust the accuracy
- ◯ Data privacy
- ◯ Not interested / Not necessary
- ◯ I have a smartphone that works like a wearable
- ◯ Other

30. If you are to use a wearable, what type would you consider using? *

Please choose **only one** of the following:

- ◯ Fitness Tracker/Activity Tracker
- ◯ Smartwatch
- ◯ Intelligent/Smart Clothing
- ◯ Others [ ]

31. Which of these potential wearable device features would you find most valuable? *

Please choose **all** that apply:

- ☐ Activity: Distance & Time
- ☐ Steps: Walk & Run
- ☐ Sleep: Record & Analyze
- ☐ Calories burned
- ☐ Calorie’s consumption(food & water)
- ☐ Multi-Sport: Running+ Swimming + Cycling+ Cross Training
- ☐ General health status: Stress level + Heart rate + Blood glucose + Blood pressure + Saturation level

32. How much do you agree/disagree with the following statements? Wearable device can be a motivational tool... *

Please choose the appropriate response for each item:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
To improve appearance	○	○	○	○	○
To improve fitness	○	○	○	○	○
To improve health	○	○	○	○	○
For weight loss	○	○	○	○	○
To monitor activities	○	○	○	○	○
To improve physical activity	○	○	○	○	○

33. How much do you agree/disagree with the following statements? A wearable device can help one to.. *

Please choose the appropriate response for each item:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Incorporate more physical activities into everyday life	○	○	○	○	○
Eat and consume healthier	○	○	○	○	○
Improve sleep	○	○	○	○	○
Manage stress level better	○	○	○	○	○
Manage general health status	○	○	○	○	○
Incorporate healthy routines into everyday life	○	○	○	○	○

34. How much do you agree / disagree with the following statements? Using a wearable device can make users feel... *

Please choose the appropriate response for each item:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Cool	○	○	○	○	○
Accountable	○	○	○	○	○
Empowered	○	○	○	○	○
Motivated	○	○	○	○	○
Self-conscious	○	○	○	○	○
Anxious	○	○	○	○	○
Guilty	○	○	○	○	○
Frustrated	○	○	○	○	○

35. In your opinion, which factors can contribute to adoption of wearable devices? *

Please choose **all** that apply:

- ☐ Functionality (useful health metrics)
- ☐ Comfortable to wear
- ☐ Good battery life
- ☐ Ease to use
- ☐ Accuracy and reliability of data recorded
- ☐ Device's ability to influence lifestyle
- ☐ Confidentiality and privacy of data

36. If you know that wearable devices can offer important health information, such as blood pressure, blood oxygen saturation, stress level, heart health etc... Would you consider using one? *

Please choose **only one** of the following:

No ◯ Maybe ◯ Yes ◯

37. I think that using a wearable device can help me improve my overall health. *

Please choose **only one** of the following:

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly agree

Section F: Physical Activities and Lifestyles Factors

Physical activity is defined as any body movement that involves energy expenditure generated by skeletal muscles, including activities carried out while working, playing, performing household chores, traveling and participating in recreational activities.

38. Do you think wearable devices can influence physical activity engagement? *

Please choose **only one** of the following:

No ◯ Maybe ◯ Yes ◯

39. Do you think your physical activities level changed in the last 12 months? *

Please choose **only one** of the following:

No ◯ Maybe ◯ Yes ◯

40. Which physical activity level category do you consider yourself?? *

Please choose **only one** of the following:

◯ Sedentary (No moderate or vigorous activities / less than 30 minutes of intentional exercise or activities per day)

◯ Lightly Active (Daily exercise that is equal to walking for 30 minutes / 15 - 20 minutes of vigorous activity on daily basis)

◯ Active (Daily exercise that is equal to walking for 1 hour and 45 minutes / 50 minutes of intense exercise per day)

◯ Very Active (Daily exercise that is equal to walking for 4 hours and 15 minutes / 2 hours intense exercise per day)

41. To what extent do you think wearable device can impact lifestyle? *

Please choose **only one** of the following:

◯ Not at all

◯ To some extent

◯ To a moderate extent

◯ To a great extent

42. Thinking about the last 12 months, how much do you agree/disagree with the following statements? I... *

Please choose the appropriate response for each item:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Incorporate more physical activities in my everyday life	◯	◯	◯	◯	◯
Eat and consume healthier	◯	◯	◯	◯	◯
Sleep better	◯	◯	◯	◯	◯
Manage stress level better	◯	◯	◯	◯	◯
Manage general health status	◯	◯	◯	◯	◯
Incorporate healthy routines into my everyday life	◯	◯	◯	◯	◯

You have reached the end of this survey. Thank you for participating in this study.

Appendix II: Declaration

Declaration

I hereby declare that this thesis entitled **"Impact Evaluation of Wearable Devices on Physical Activity and Healthy Lifestyles"** is carried out independently by me under the guidance of **Prof. Dr. Andre Klussmann** and **Dr. (MPH) Adekunle Adedeji.** I have explicitly cited all material that has been quoted either literally or by content from the used source.

Date: **09.09.2020**

Name: **Opeyemi .M. Ayanwale**

Place: **Hamburg, Germany**

Signature: