Impact of smart wearable devices on physical activity and motivation

A hordozható technológiai eszközök hatása a fizikai aktivitás végzésére és a motivációra

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Abstract

This study examines the relationship between wearable technology devices, physical activity (PA) levels, and motivation among university students using the self-determination theory (SDT) framework. Two hundred and twenty-three Kenyan university students participated in the study. Motivation was measured using the BREQ-3 questionnaire, while PA levels were measured using the GPAQ. Results showed significant differences in PA levels between wearable technology users (M=3283.26) and non-users (M=2170.75), especially about exercise-related PA. No significant differences were found between PA and active transportation and device users and non-users. Users of wearable technology devices showed higher intrinsic motivation (M=41.55, p=0.006), integrated regulation (M=25.53, p=0.005), and identified regulation (M=13.28, p=0.028). In particular, post hoc test results indicated that introjected regulation was a significant predictor of PA among users of wearable technology for PA tracking (M=-11.59, p=0.044). Our study results supported the positive effect of wearable technology devices in enhancing PA motivation and commitment to PA. The potential of wearable technology to facilitate the achievement of globally recommended levels of PA for disease prevention as well as health-promoting leisure activities, and active lifestyles was confirmed.

Keywords: wearable technology, physical activity, motivation, tracking devices

Összefoglaló

A tanulmány egyetemi hallgatók körében vizsgálja az önmeghatározás elmélet (SDT), mint keretrendszer felhasználásával, a hordozható technológiai eszközök, a fizikai aktivitási (PA) szint és a motiváció közötti kapcsolatot. A kutatásban 223 kenyai egyetemi hallgató vett részt. A motivációt a BREQ-3 kérdőívvel, míg a PA-szinteket a GPAQ segítségével mértük. Az eredmények jelentős különbséget mutattak a PA-szintekben, a PA-követésére szolgáló hordozható technológia használói (M=3 283,26) és a nem használók (M=2 170,75) között, különösen a testmozgással kapcsolatos PA tekintetében. A PA és az aktív közlekedés között nem találtunk szignifikáns különbséget az eszközhasználók és nem használók között. A hordozható technológiai eszközöket használók magasabb intrinzik motivációt (M=41,55; p=0,006), integrált szabályozást (M=25,53; p=0,005) és azonosított szabályozást (M=13,28; p=0,028) mutattak. Elsősorban a post hoc teszt eredmények jelezték azt, hogy a PA nyomon követésére szolgáló hordozható technológia használói körében az introjektált szabályozás szignifikáns előrejelzője a PA-nak (M=-11,59; p=0,044). A vizsgálat eredményei alátámasztották a hordozható technológiai eszközök pozitív hatását a PA-motiváció és a PA-hoz való kötődés fokozásában. Megerősítést nyert a hordozható technológiában rejlő azon lehetőség, amely elősegítheti a világszerte ajánlott PA-szintek elérését a betegségek elkerülése, az egészségfejlesztő szabadidős tevékenységek és az aktív életmód kialakítása érdekében.

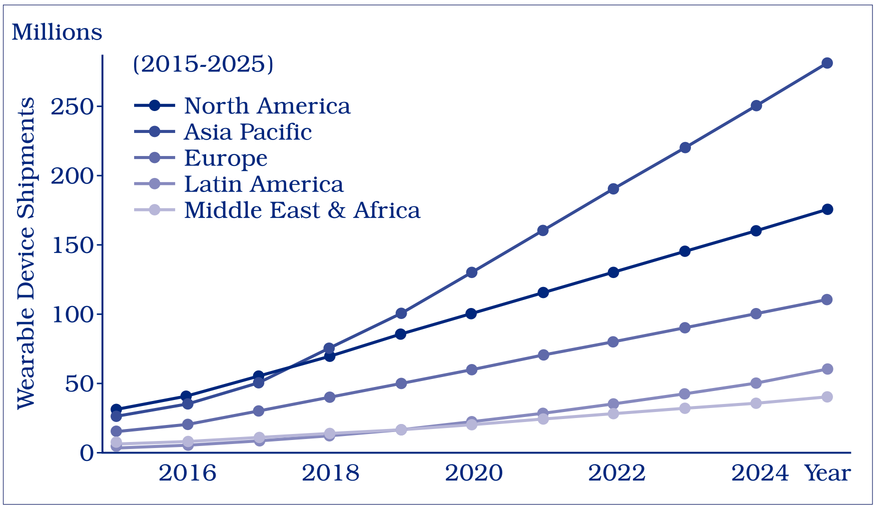

Figure 1. Global wearable technology sales by region in the last decade

1. ábra. Hordozható technológiai eszközök eladása régiónként az elmúlt évtizedben

Kulcsszavak: hordozható technológia, fizikai aktivitás, motiváció, nyomkövető eszközök

Introduction

Insufficient physical activity (PA) is among the major causes of lifestyle-related illnesses. Conversely, even a small increase in PA can result in a significant reduction in susceptibility to diseases such as diabetes, heart disease, osteoporosis, and other non-communicable diseases (Bice et al., 2015). According to the World Health Organization (WHO), 27% of adults and 80% of adolescents do not meet the WHO's recommended level of PA (WHO, 2023).

WHO issued the Global Action Plan on Physical Activity 2018-2030 (GAPPA), which provides recommendations to countries for improvement of PA levels among their populace with a target of at least a 15 percent reduction in physical inactivity level by the year 2030 (WHO, 2022). Kenya exhibits a dual landscape of physical activity behaviours, shaped by urbanization, socioeconomic disparities, and cultural norms. While rural populations often engage in high-level PA due to occupational and domestic labour, urban youth, including university students, are increasingly exposed to sedentary behaviour. According to Mwangi et al. (2019), 46.5% of university students did not meet the recommended levels of moderate PA. Several interventions over the years have not succeeded in getting the public more involved and motivated to maintain adherence to PA. However, the recent ubiquitous technology has provided potentially high effectiveness in PA adherence interventions. Notably, wearable technology involves the use of devices such as smart watches, smart bracelets, accelerometers, and mobile phones, among others, which have proved a significant breakthrough in the enhancement of PA. The physical activity tracking devices allow users to monitor their physical activity patterns. Users can set daily, weekly, or monthly PA targets (Galea et al. 2020). Some devices provide opportunities to connect with virtual coaches and benchmark themselves against other users around the world.

In recent years, there has been a booming sale of physical activity tracking devices around the world. There are about 172 million recorded annual sales of smart watches in the world, and health consciousness (PA awareness) is among the leading reasons for their increasing demand, which is projected to grow to 584 million by the year 2029 (Mordor Intelligence, 2024). While North America and Europe continue to dominate the wearable technology market, Africa is emerging as a high-potential region, as visualized in **Figure 1**.

In Kenya, the adoption of wearable technology is accelerating, aided by the digitally literate youth and heightened awareness of lifestyle-related health risks. However, PA remains a critical public health concern. There is a need to establish whether the use of movement tracking devices has any relationship with PA awareness and whether their use has an impact on motivation towards PA. This article sought to establish the differences in motivation levels and physical activity awareness between the users and non-users of movement tracking devices. This study offers insights into the place of wearable technology in promoting a healthy lifestyle. The study employs Self-Determination Theory (SDT) (Deci and Ryan, 1985) to investigate the relationship between wearable technology and motivation for physical activity adherence. Deci and Ryan (2000) developed a Self-Determination Theory Continuum, showing different types of motivation with their regulatory styles, locus of control, and their corresponding processes. There are six motivation constructs on SDT continuum, ranging from Amotivation (lack of intent; controlled) to intrinsic regulation (enjoyment and satisfaction; autonomy). Many people engage in PA because they derive enjoyment and fun, with a feeling of pleasure and enjoyment. However, external factors such as skill requirements, cultural and social background have an impact on PA participation. Physical activity tracking devices contain both intrinsic and extrinsic motivation aspects, and therefore, SDT will help provide a better understanding of the motivation aspects provided by tracking devices.

Material and Methods

Study design and sampling

Approval was obtained from the Research Ethics Committee of the Hungarian University of Sports Science, approval number TE-KEB/15/2024. Approval to collect data in Kenya was granted by the National Commission for Science, Technology and Innovation with the license number NACOSTI/P/24/38648. This study used the survey design method and included 251 university students from 29 Kenyan universities (22 public universities and 7 private). All students enrolled in any undergraduate program were eligible to participate in the survey, regardless of their level of involvement in sports activities. University students represent a transitional group in terms of health behaviour and development. They are digitally connected, socially engaged and increasingly health conscious, yet they face barriers to regular PA due to time constraints, lack of institutional support, and motivation. A stratified random sampling technique was used to ensure homogeneous representation among academic disciplines, levels of study, socio-economic backgrounds, and physical activity levels.

Data were collected using the following Questionnaires:

- Global Physical Activity Questionnaire (GPAQ). GPAQ is the World Health Organization's recommended tool for measuring physical activity across all populations. It measures physical activity levels attained as a result of moderate and vigorous work, active transport, and moderate to vigorous exercise, ranging from organized sports to recreational sports activities (WHO, 2021). Respondents report on the amount of time spent at work, organized sports activities, and active transport such as walking and cycling.
- Behavioral Regulation in Exercise Questionnaire (BREQ-3). BREQ-3, a validated questionnaire developed by Markland & Tobin (2004), was used to assess the six SDT motivation aspects on a 5-point Likert scale. It contains 24 items with each sub-scale consisting of 4 items representing each of the motivation construct e.g. I don't see why I should have to exercise (Amotivation); I exercise because other people say I should (External Regulation); I feel guilty when I don't exercise (Introjected Regulation); It's important to me to exercise regularly (Identified Regulation); I consider exercise part of my identity (Integrated Regulation) and I exercise because it's fun (Intrinsic Regulation). Reliability of the BREQ-3 responses was tested using Cronbach's α, which ranged between (α=0.74) and (α=0.86), indicating their reliability was acceptable among all the responses.

Procedure

Both GPAQ and BREQ-3 were combined in a single Google Form questionnaire, with BREQ as section one and GPAQ as section two. The third section of the questionnaire involved a few questions about the use of physical activity tracking devices, where respondents indicated if they use or don't use PA tracking devices and how they use them. A QR code was generated to create easy access to the questionnaire. Respondents were approached physically and others online through Facebook and Instagram. Those approached physically were requested to scan the QR code, while those approached through online channels were sent the online link to the questionnaire.

Statistical analysis

Data obtained from the GPAQ were cleaned and consolidated following the WHO-recommended guidelines (WHO, 2021). BREQ-3 scores were consolidated and analyzed as recommended by Markland (2014). Data were analyzed using SPSS version 29.0.2.0. Analysis included the descriptive statistics to identify frequencies, means, and percentages. One-way ANOVA was conducted to assess the relationship between the use of technology on physical activity and to establish the effect of wearable devices on physical activity motivation. 6x2 MANOVA analyses were conducted using the six motivation con-

Table 1. Physical activity levels in male and female participants
1. táblázat. A fizikai aktivitás szintje a vizsgálatban résztvevő férfiaknál és nőknél

Physical Activity Level	N			Percentage		
	Female	Male	Total	Female	Male	Total
High PA	50	104	154	61.0	73.8	69.1
Moderate PA	22	22	44	26.8	15.6	19.7
Low PA	10	15	25	12.2	10.6	11.2
Total	82	141	223	100	100	100

Table 2. ANOVA test results for different wearable technology device use groups
2. táblázat. ANOVA teszteredmények a különböző hordozható technológiai eszközök használatára vonatkozó csoportok esetében

		N	Mean PA (MET minutes)	sig.
Exercise	PA Tracking	118	3 283.26*	0.018
	Other Uses	19	2 390.53	
	None	86	2 170.75*	

* The mean difference is significant at the 0.05 level

structs as the dependent variables and PA Levels and wearable device use as the independent variables.

Results

Physical activity

Physical activity was measured in Metabolic Equivalent of Task (MET) minutes. One MET value represents the energy cost while at rest. Total MET was obtained by multiplying the amount of time (in minutes) spent on work, active transport, and sports activities by the weighting allocated to the activity depending on its intensity. Physical activity can be categorized as low, moderate, or high depending on the total MET minutes achieved per week. Low PA consists of a score below 600 MET minutes, which does not meet the minimum recommended PA. Moderate PA is a score above 600 but below 3 000 MET minutes, while a score above 3 000 consists of high PA (WHO, 2021) as demonstrated in **Table 1.**

69,1% (n=154) of the respondents had high PA levels against 11.2% (n=25) who recorded low PA levels, while 19.7% (n=44) met moderate PA levels. Generally, males recorded higher PA, 73% (n=104) compared to females, 61.0% (n=50). However, females had a significantly higher percentage of moderate PA (26.8%; n=22) compared to their male counterparts (15.6%; n=22).

Physical activity and wearable devices

The study compared the contributions of work, active transport, and sports activities to the total PA against the use of wearable technology devices (smart watches, smart bracelets, accelerometer and mobile phone exercise apps). Participants reported on their use of wearable technology in three categories: those who use them for physical activity tracking (52.9%; n=118), other uses than physical activity tracking (8.5%; n=19), and those who never used wearable technology devices (38.6%; n=86).

A one-way ANOVA was performed to compare the effect of technology devices on the PA (**Table 2**). The results revealed that the score for sports activities between the users of wearable technology for tracking PA (M=3283.26; SD=3455.37) and the non-users (M=2770.75; SD=2123.17) was statistically significant, F (2, 57.58)=3.45, p=0.04. Tukey's HSD tests for multiple comparisons showed that the mean PA for users of wearable devices was significantly higher than that of non-users of wearable devices ($p<0.05$). There was no statistically significant difference in work and active transport-related PA across the groups.

Motivation and wearable technology devices

Motivation was measured using BREQ-3 (Markland and Tobin, 2004). The questionnaire measured the six aspects of motivation, that is, Amotivation, external regulation, introjected regulation, identified regulation, integrated regula-

Table 3. Motivation scores for various wearable technology device users
3. táblázat. Motivációs pontszámok a különböző hordozható technológiai eszközök felhasználóinál

	Wearable Technology Device Use			Sig. (One-Way ANOVA)
	Tracking PA	None	Other Uses	
Motivation Subscale	Means (SD)			
Amotivation	0.52 (0.890)	0.41 (0.664)	0.88 (1.220)	0.041*
Introjected Regulation	2.84 (1.092)	2.48 (1.103)	2.91 (1.149)	0.016*
Integrated Regulation	3.04 (1.040)	2.73 (1.108)	3.04 (1.042)	0.043*

Table 4. Post Hoc test results on motivation differences across various groups of wearable technology device users
4. táblázat. Post Hoc teszteredmények a motivációs különbségekről a hordozható technológiai eszközök különböző csoportjaiban

	(I)PA Tracking Device Use	(J)PA Tracking Device Use	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Introjected Regulation	PA Tracking	None	0.35366*	0.13135	0.020	0.0443	0.6630
		Other Uses	-0.07253	0.27145	0.961	-0.7119	0.5668
	None	PA Tracking	-0.35366*	0.13135	0.020	-0.6630	-0.0443
		Other Uses	-0.42619	0.26687	0.248	-1.0548	0.2024
Integrated Regulation	PA Tracking	None	0.31148*	0.12850	0.042	0.0088	0.6141
		Other Uses	-0.00086	0.26555	1.000	-0.6263	0.6246
	None	PA Tracking	-0.31148*	0.12850	0.042	-0.6141	-0.0088
		Other Uses	-0.31234	0.26107	0.456	-0.9272	0.3026

* The mean difference is significant at the 0.05 level

tion, and intrinsic regulation. Various motivation scores were identified across the different groups of technology device users, as shown in **Table 3.**

One-way ANOVA was performed to identify the significance of wearable technology on PA motivation. The results revealed significant differences in Amotivation [F(2.303)=3.22, p=0.041)], introjected regulation [F(2.303)=4.18, p=0.016] and integrated regulation [F(2.303)=3.18, p=0.043]. No significant differences were found with other motivation constructs.

Tukey HSD test for multiple comparisons revealed that users of wearable technology had significantly higher introjected regulation ($p<0.05$) and integrated regulation ($p<0.05$) compared to non-users of wearable technology devices (**Table 4**).

Motivation and gender

To examine the differences in motivational regulation, independent samples t-test was conducted across the six motivation constructs. Amotivation scores were lower among females (M=0.32; SD=0.52) than males (M=0.54; SD=0.94). Females also had lower external regulation (M=0.41; SD=0.58) compared to males (M=0.70; SD=0.92). There were relatively similar scores in other motivation constructs, although males showed slightly higher scores.

Levene's test for equality of variances was applied to assess homogeneity of variance. A statistically significant difference in Amotivation was found between males and females [F (220.46)=-2.387, p=0.0018], with males recording higher Amotivation. Significant gender differences were also revealed in external regulation [F (219.66)=-2.936), p=0.004], with males having stronger external regulation.

Motivation and Physical Activity

The test of between-subject effects exhibited that external regulation was associated with significant differences in PA adherence due to the use of tracking devices, as shown on **Table 5.**

No significant differences were found among other motivation factors, indicating that wearable devices only had a significant effect on external regulation. Interaction between PA levels and device use varied based on device usage (F=1.834; p=0.023), indicating that external motivation, together with device usage, was a strong predictor of physical activity adherence.

Table 5. 2by2 MANOVA results comparing motivation and physical activity levels among various groups of wearable technology device users
5. táblázat. 2by2 MANOVA teszteredmények a motiváció és a fizikai aktivitás szintjének összehasonlításában a hordozható technológiai eszközöket viselő különböző csoportok tagjai között

Tests of Between-Subjects Effects						
Independent Variable	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Total_PA_MET	Amotivation	11 580.642	133	87.072	0.895	0.699
	External_Regulation	6 270.435	133	47.146	1.659	0.018*
Total_PA_MET * PA_ Tracking_Device_Use	Amotivation	4 131.082	33	125.184	1.286	0.202
	External_Regulation	1 720.401	33	52.133	1.834	0.023*

* The mean difference is significant at the 0.05 level

Discussion

The results showed that males have generally higher physical activity levels than females, which corresponds with Bauman et. al (2009) and Bull et al. (2009) that younger male adults were more active than their female counterparts in most countries.

The findings reveal that male students exhibit significantly higher levels of Amotivation and external regulation than female students, suggesting that male students experience greater disengagement and their motivation to engage in PA is more influenced by external factors.

The analysis confirmed that wearable technology devices significantly enhance exercise-related PA, although they have less impact on work and transport-related PA. Kercher et al. (2024) noted the importance of psychological motivation factors and their role in making exercise decisions and maintenance of exercise behaviour. The results are also in line with findings from Longhini et al. (2024), who found that wearable devices improved PA by a median of 1 312.23 steps per day from 679 steps a day before intervention, and increased moderate to vigorous physical activity by 57.8 minutes per week following wearable devices intervention. In contemporary societies, the influx of wearable technology has enhanced access occasioned by the availability and affordability of tracking devices, especially smart watches, bracelets, and smart phones.

Effect of Wearable Technology on Motivation

Users of wearable technology devices for tracking PA showed higher scores in intrinsic motivation scores, denoting that users have a higher tendency to internalize physical activity within their daily life. ANOVA results revealed significant differences between the users and non-users of wearable technology devices. The groups showed significant variances in Amotivation, introjected regulation, and integrated regulation constructs. Wearable technology devices enable users to set PA goals and record the PA level at the end of the day and week. The devices remind users about important health habits such as movements, drinking water, sleep and users can check their blood pressure, heart rate, and body temperature. These indicators serve as the external controls that help the users track their physical activity. Users can socially connect with other device users, within their locality and globally, and view others' achievements, affecting their external regulation and introjected regulation in benchmarking efforts. However, some users give up when they can't cope with the demands, which might lead to a loss of interest in physical activity, resulting to Amotivation.

The results support earlier findings that external motivators such as feedback obtained from technology devices can create a behaviour change (Fortier et al. 2012). The higher introjected regulation may suggest the feeling of guilt when daily targets are not met, supporting Teixeira et al. (2012) that external motivators can play the introduction and adoption role, but intrinsic motivation is required for continued adherence to PA. Kokts-Porietis et al. (2018) highlighted that wearable technology helps to enhance external regulation for PA, but it should be paired with supportive interventions to foster intrinsic motivation for long-term adherence to PA. Bice et al. (2015) confirmed a change in exercise motivation through the use of wearable technology devices. Kerner and Goodyear (2017) added that wearable technology devices help to improve the autonomy aspect of motivation when it allows individuals to set their own daily PA targets and work towards improving them. Although being an external motivation-enhanced intervention, wearable devices can condition the user to internalize PA, which in turn shifts their motivation towards the autonomy side.

Influence of Wearable Technology on PA

MANOVA results revealed that intrinsic regulation, integrated regulation, and identified regulation were strong predictors of physical activity. These motivation constructs are on the autonomous side of the SDT continuum, which means that people demonstrating them have a positive drive towards physical activity. The results also confirmed that external regulation and introjected regulation only predicted PA as a result of wearable technology device use. Introjected regulation represents the controlling non-self-determined type of extrinsic motivation because participants do not attach the behaviour to their choice, but from external psychological pressure (Englert and Tylor, 2021). Introjection is an internal pressure where an individual participates in PA to achieve recognition or avoid guilt (Narváez et al. 2019). The study results for the effect of using tracking devices on external regulation confirmed the observation by Scheid and West (2019) that wearable technology improved daily physical activity for lower baseline PA individuals. Yen and Chiu (2019) identified a significant difference in sedentary behavior, with the current users showing significantly less sedentary behavior than former users. Galea et al. (2020) alluded that wearable technology is an untapped health intervention resource with the potential to greatly improve PA even in environments with limited resources. While acknowledging the importance of wearable technology, Pope et al. (2019) advised considering other intervention strategies to help boost PA levels among college students.

Conclusion

The study highlighted the significance of wearable technology devices on motivation and PA levels. The findings reveal that users of physical activity tracking devices demonstrate higher levels of intrinsic and integrated motivation, suggesting that wearable devices play a pivotal role in promoting self-driven initiatives in physical activity participation. Whereas the results suggested that external regulation and introjected regulation aspects of motivation are also enhanced through wearable technology device features such as goal setting and social comparisons, fostering intrinsic motivation is fundamental to attain long-term adherence to physical activity.

Wearable technology underscores its potential in improving exercise-related physical activity despite its limited impact on work and transport-related physical activity. The study supports the integration of wearable technology devices as an effective tool for enhancing physical activity awareness and motivation. As global organizations and governments create efforts towards the enhancement of physical activity as a means of prevention and management of non-communicable diseases and lifestyle-related illnesses, wearable technology is a considerable addition to their intervention strategies.

Köszönetnyilvánítás: A tanulmány a Magyar Testnevelési és Sporttudományi Egyetem támogatásával történt, köszönet érte.

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