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ADULT PHYSICAL ACTIVITY, SEDENTARY BEHAVIOUR AND SLEEP QUALITY IN THE DIGITAL TRANSFORMATION ERA

Andra Fernāte

Žermēna Vazne

Anna Zuša

Inta Bula-Biteniece

Irēna Dravniece

Juris Grants

Jānis Žīdens

Monta Jakovļeva
Latvian Academy of Sport Education, Latvia

Abstract. *The digital transformation era increases population health risks associated with lack of exercise, as well as emphasizes the role of an active lifestyle within sustainable socio-economic development. Digitalization is one of the main reasons for setting significant public health priorities: poor or insufficient sleep and physical inactivity. The aim of the research was to study the physical activity (PA), sedentary behaviour (SB) and sleep duration of the population measured by a tri-axial accelerometer. Methods: The study is based on the project "EUPASMOS", where PA, SB, and sleep-time of the participants (n = 369) was measured 24/7 by a tri-axial accelerometer (UKK RM42, UKK Terveyspalvelut Oy, Tampere, Finland) for a week-long period. The participants mostly spent their waking hours in a sedentary state. The mean duration of sedentary behaviour was 7h 52min. The participants took an average of 9584 steps a day. They also engaged in light PA for 4h 15min, and moderate-to-vigorous PA for 1h 16min. The mean duration of sleep was 5h 46min. The results showed that the insufficient sleep and physical inactivity of the participants are serious health risks in the digital transformation era. Future research should focus on the effect that various components of physical activity (dose, mode, timing) have on sleep.*
Keywords: *adult physical activity, EUPASMOS, sedentary behaviour, sleep quality.*

Introduction

Promoting physical activity during development is a public health priority, and many studies emphasize the benefits of a variety of structured and unstructured activities in preventing non-communicable diseases and promoting health (Colella & Bellantonio, 2019). Daily structured and unstructured motor activities also help to promote individual development of personality. An in-depth

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study of physical activity among the working age population (18–59 years old) is drawing ever-increasing interest (Herrmann et al., 2024).

The digitalization era promotes a sedentary lifestyle, but human capital is the key to sustainable development, as physical capital, information technology and other factors of production may not work without it (Qureshi, 2023). Research-based evidence shows that the amount of physical activity and sedentary behaviour patterns have a negative impact on health. Therefore, one of the most important directions to be considered by policymakers is related to the opportunity to promote physical activity in society and reduce inactivity by implementing these changes in all areas of life (Stamatakis & Hamer, 2011).

Poor sleep quality is significantly associated with poor quality of life (Lee, Chung, & Kim, 2021). The aging process of humans is directly related to sleep disorders, where insomnia has a negative impact on the quality of life of middle-aged and elderly people, altering their cognitive and metabolic functions. Moreover, research indicates that physical activity is positively related to improvement in sleep quality (Silva et al., 2023). Such findings were also obtained in previous studies, where the positive effects of regular and dosed physical activity on changes in lifestyle were noted, where physical activity can serve as one of the non-pharmacological means of sleep regulation (Léger, Poursain, Neubauer, & Uchiyama, 2008). Furthermore, research suggest that individuals who participate in moderate physical activity experience fewer complaints of sleep disorders and enjoy enhanced sleep quality (Sejbuk et al., 2022). Additionally, they exhibit elevated levels of cognitive skills and cognitive functions (Robles-Granda et al., 2021), increased work abilities, and productivity (Tarro, Llaurado, Ulldemolins, Hermoso & Sola, 2020).

There is also a correlation between adult physical activity, sedentary behaviour, and sleep quality (Koohsari et al., 2023). A full-fledged sleep is an important factor in maintaining health and improving well-being. When studying the relationship between sleep quality and physical activity, and sedentary lifestyle in the Japanese adult population with the help of accelerometers, a statistically reliable impact of physical activity on the sleep quality of middle-aged women was found, while no such relationship was found for men within the scope of the study (Koohsari et al., 2023). The amount of sleep necessary for each age group is different, but on average it is 7 to 9 hours (Paruthi et al., 2016; Watson et al., 2015). However, statistics show that a third of adults spend less time sleeping than is recommended (Saelee, Haardörfer, Johnson, Gazmararian & Suglia, 2023; Sin, Wen, Klaiber, Buxton & Almeida, 2023). Research analysis indicates that insufficient sleep negatively affects cardiovascular, endocrine, and immune function, body composition, and the mortality risk (Cappuccio, D'Elia,

Strazzullo, & Miller, 2010; Cappuccio & Miller, 2017; MartinezAguirre-Betolaza et al., 2019).

Insufficient sleep duration and poor sleep quality have also been shown to correlate with limited physical activity, where better sleep quality is more often associated with more intense levels of physical activity (Stefan et al., 2018). Overall, results suggest that increasing PA levels will improve sleep and reduce SB (Mead, Baron, Sorby, & Irish, 2019), although some studies found little or no effect on total SB time reduction (Kredlow, Capozzoli, Hearon, Calkins & Otto, 2015). One possible method for estimating PA intensity is the use of metabolic equivalents (METs) (Ainsworth et al., 2011), where the intensity of physical activity can be expressed in a metabolic equivalent of a task - MET, which is the ratio of work metabolic rate to a standard resting metabolic rate of 1.0 (4.184 kJ) $\times$ $kg^{-1} \times h^{-1}$, 1 MET is considered a resting metabolic rate obtained during quiet sitting (Ainsworth et al., 2000). The Pate et al. (1995) model classifying the MET intensity of PAs: light, < 3 METs (< 4 kcal X min^{-1}); moderate, 3-6 METs (4-7 kcal X min^{-1}); vigorous, > 6 METs (> 7 kcal X min^{-1}), while sedentary behaviour (SB), 1-1.5 MET, and light-intensity PA was further specified (1.6–2.9 MET) (Pate, O'Neill & Lobelo, 2008).

Physical inactivity is one of the four leading risk factors for global mortality (WHO, 2022), non-communicable diseases, mental health conditions (Santos et al., 2023), and an accurate measurement of physical activity (PA) remains a challenge (Helmerhorst, Brage, Warren, Besson, & Ekelund, 2012). Moreover, physical inactivity is linked to sleep quality (Yang, Shin, Li & An, 2017; Creasy et al., 2019; Jeong et al., 2021; Arakaki et al., 2022). Poor or insufficient sleep and physical inactivity are significant public health priorities (Kline, 2014) in the digital transformation era. Sleep is classified into three categories: awake, restless, and restful (van Hees et al., 2015; Vasankari et al., 2019). Additional research into the relationship between physical activity and sleep is important.

The aim of the research was to study the physical activity (PA), sedentary behaviour (SB), and sleep-time of the population measured by a tri-axial accelerometer.

Methodology

To reach the aim of the research, the physical activity (PA), sedentary behaviour (SB), and sleep-time of the population was measured 24/7 by a tri-axial accelerometer (UKK RM42, UKK Terveyspalvelut Oy, Tampere, Finland) for a week-long period. The accelerometer was worn on an elastic hip-band during waking hours, and on a wristband attached to a non-dominant wrist during bedtime (sleeping)**,** except during water activities (e.g., swimming, showering, sauna visits). PA-parameters were based on the mean amplitude deviation (MAD) of acceleration analysed in 1 min exponential moving average (epoch length 6s).

The assessment of SB (e.g., sitting and laying down) and standing was based on the angle for posture estimation (APE). The sleep measurement was based on the periods of non-dominant wrist movement (of SB, standing (Stand), light PA (LPA), moderate-to-vigorous PA (MVPA), sleep) and the mean number of daily steps. The study is based on the European project "EUPASMOS", where the PA, SB, and sleep-time of the participants (n = 369 adults) was determined. Descriptive and inferential statistics were used for data analysis.

Research Results

The research participants wore accelerometers for an average of 22 hours and 19 minutes every day during the seven-day period, of which it was worn on an elastic hip-band during waking hours for 15 hours and 12 minutes, and on a wrist-band attached to a non-dominant wrist during bedtime (sleeping) for 7 hours and 7 minutes, except during water activities (e.g., swimming, showering, sauna visits), which amounted to 1 hour and 41 minutes.

The accelerometery data show that the research participants are sedentary for an average of 7 hours and 52 minutes per day, standing for 1 hour and 47 minutes, performing light PA for 4 hours and 15 minutes, performing moderate-to-vigorous PA for 1 hour and 16 minutes, and performing vigorous PA for an average of only 4 minutes a day. Therefore, for more than 50% of the average waking hours per week adults are sedentary, for 12% of the average waking hours per week they are standing, and for 36% of the average waking hours per week, they are engaging in PA (Fig.1).

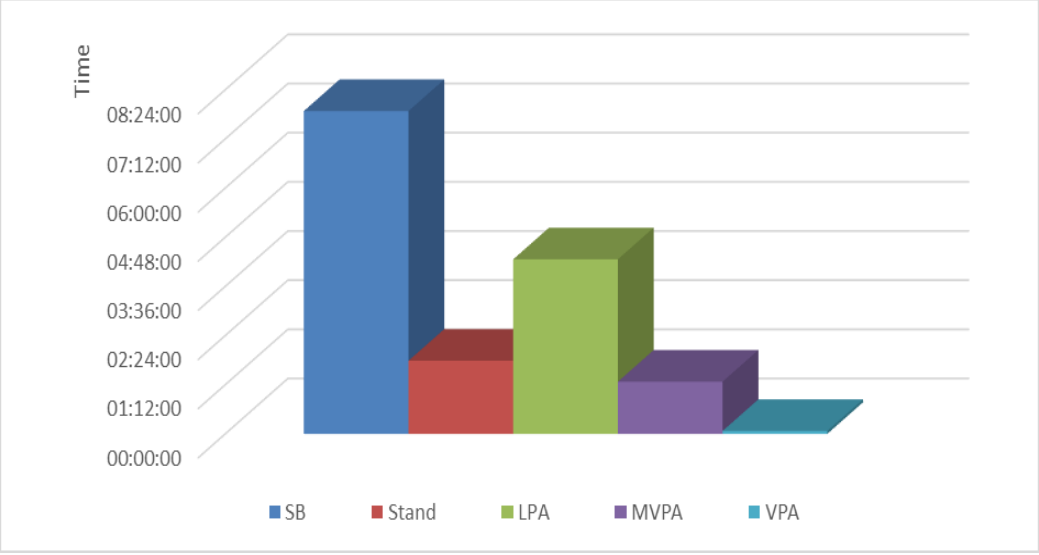

Figure 1 ***Characteristics of the Average Adult Behaviour per Day (h/min/sec) per Week During Waking Hours (n= 369)***

The adult physical activity time (MET > 1.5) from bouts less than 5 minutes is performed for 2 hours and 33 minutes, while physical activity time (MET > 1.5) from bouts between 5-10 minutes is performed for 1 hour, and physical activity time (MET > 1.5) from bouts over 10 minutes is performed on average for 1 hour and 57 minutes per day during the week. Therefore, for more than 46% of the average waking hours per week adults engage in short-term PA, which are shorter than 5 minutes, while 18% of the activity time is spent on 5-10 min long PA, and 36% of the activity time is spent on more than 10 min long PA (Fig.2).

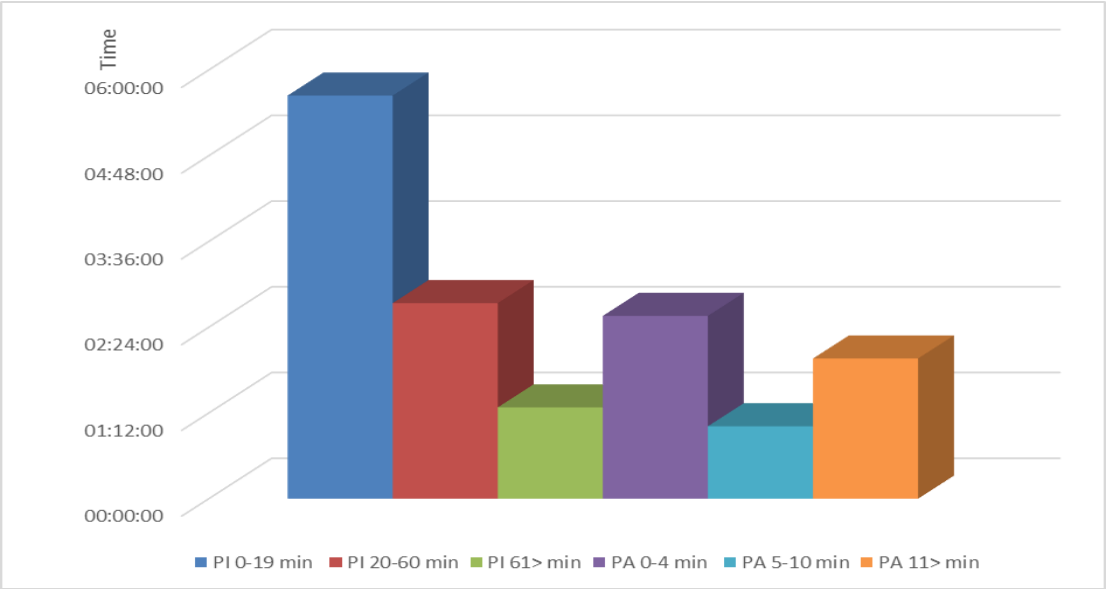

Figure 2 ***Characteristics of the Average Adult Physical Activity (PA) and Physical Inactivity (PI) per Day (h/min/sec) per Week During Waking Hours (n=369)***

In turn, the adult physical inactivity time is characterized by immobility or stationary time (MET < 1.5) from bouts less than 20 minutes for an average of 5 hours and 38 minutes per day during the week, stationary time (MET < 1.5) from bouts between 20-60 minutes for 2 hours and 44 minutes, while inactivity longer than 60 minutes amounts for 1 hour and 58 minutes of the average waking hours per week. Furthermore, physical inactivity lasting less than 20 minutes amounts to 58% of total sedentary time during average waking hours of adults per week.

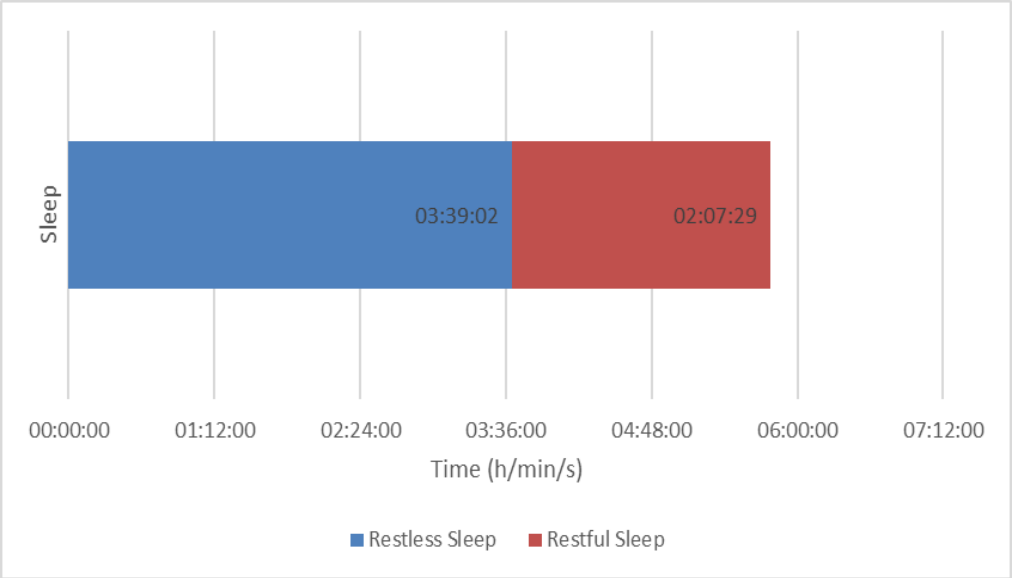

Figure 3 ***Characteristics of the Average Adult Sleep Quality per Week (n=369)***

Adults sleep an average of 5 hours and 46 minutes per day per week, where restless sleep time is 3 hours and 39 minutes, during which medium movement can be observed, and restful sleep time is 2 hours and 7 minutes, which is characterized by low movement. On average, restless sleep time constitutes 63% of the total sleep time for adults per day per week (Fig.3). Moreover, adults took an average of 9584 steps per day per week.

Correlation coefficients between the average steps per day and restless sleep time (r_s= -0.117, $p < 0.05$) is very low, but between the average sedentary time and restless sleep time (r_s= -0.209, $p < 0.01$), restful sleep parameters (r_s= -0.189, $p < 0.01$) are low.

Discussion and Conclusions

The participants mostly spent their waking hours in a sedentary state. The research results show that the mean duration of adult sedentary behaviour is 7h 52 min, while the study of the European population shows that only 7% of the population spend 7h 31min to 8h 30min sitting on a usual day, but majority of respondents (44%) report that they sit for between 2 hours 31 minutes and 5 hours 30 minutes on a usual day (European Commission, Directorate-General for Education, Youth, Sport and Culture, 2022).

On average, the participants took 9584 steps a day, and 10 000 steps a day is a reasonable target for healthy adults (Tudor-Locke et al., 2011). The research results show that adults engage in light PA for an average of 4h 15min per day, while the time spent on moderate-to-vigorous PA is 1h 13min. However, the World Health Organization 2020 guidelines on physical activity and sedentary behaviour recommend that all adults should undertake at least 150–300 min of

moderate-intensity, or 75–150 min of vigorous-intensity physical activity, or some equivalent combination per week (Bull et al., 2020). Furthermore, the research indicates that adults perform vigorous-intensity physical activity for only 4 minutes a day, which in turn shows that it will not be possible to implement the recommendations of the World Health Organization and reach the recommended 75–150 min per week. Nonetheless, the research participants exceeded the recommended 150–300 min of moderate-intensity PA.

The recommended threshold value for adult sleeping time is more than 7 hours per night (Chaput et al., 2018; Paruthi et al., 2016; Watson et al., 2015), but the research results suggest that the mean sleeping time of the research participants is only 5h 46 min, which is much less than recommended, restless sleep time is 3 hours and 39 minutes, and restful sleep time is 2 hours and 7 minutes. Differs from Yang et al. (2017) research, where no association between sedentary behavior and poor sleep quality was observed, this research contradicts and low association between sedentary behavior and sleep quality was observed. Physical inactivity can cause insufficient sleep.

The results mirror that the insufficient sleep and physical inactivity of the participants are serious health risks in the digital transformation era. Future studies should investigate whether increasing light, moderate or vigorous intensity physical activity (dose, mode, timing) and decreasing sedentary time improves sleep quality in different adult groups.

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