

Estudio de la influencia de la actividad física sobre la calidad del sueño y los niveles de atención utilizando herramientas tecnológicas

Study of the influence of physical activity on sleep quality and attention levels using technological tools

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Resumen

Este artículo presenta un estudio de caso que pretende a través de una prueba piloto, analizar la influencia de la actividad física frente a la calidad del sueño y los niveles de atención de dos ingenieros con rol administrativo, para lo cual se utilizó una interfaz cerebro computadora portable (BCI) para registrar las señales encefalográficas de atención mientras de forma simultánea se aplicó una prueba atencional tradicional (Test d2) en una plataforma de evaluación psicosocial (MenPas). Asimismo, se empleó un reloj inteligente para registrar la actividad física y calidad del sueño durante un mes laboral (2 semanas por trabajador), las 24 horas del día, donde en términos generales se encontró una influencia positiva en la realización de actividad física sobre las variables antes mencionadas.

Palabras clave: actividad física, calidad del sueño, cerebro, computadora, niveles de atención, reloj inteligente.

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Abstract

This article presents a case study that aims, through a pilot test, to analyze the influence of physical activity on sleep quality and attention levels of two engineers with an administrative role, for which a brain-computer interface was used (BCI) to record the encephalographic signals of attention while simultaneously applying a traditional attentional test (Test d2) in a psychosocial assessment platform (MenPas). Likewise, a smart watch was used to record physical activity and sleep quality during a work month (2 weeks per worker), 24 hours a day, where in general terms a positive influence was found in the performance of physical activity on the aforementioned variables.

Keywords: physical activity, sleep quality, Brain, computer, attention levels, smart watch.

Introduction

The World Health Organization (WHO) defines physical activity as any bodily movement that involves energy expenditure, such as walking, jogging, cycling, playing sports, among others [1], which provides numerous health benefits, how to reduce the probability of occurrence of pathologies of origin cardiac[2], [3], respiratory [4], metabolic[5], helps to maintain a healthy body weight [6], improve mental health such as anxiety disorders, depression [7] or stress [8] and therefore have a better quality of life [9], [10].

For example, studies have found that there is a relationship between physical activity with academic performance and cognitive functions, indicating that aerobic exercise has a positive influence on improving cognition and the formation of neurons [11]–[13]. However, the authors also suggest contrasting with more studies to indicate these relationships with different methodologies and explain their causes.

Similarly, other studies indicate that physical activity improves sleep quality, reducing insomnia and drug use in adults [14] and longer hours of sleep in children [15].

In accordance with the aforementioned studies [16]–[23] and with the objective of making use of new technologies, this article analyzes the influence of physical activity on the quality of sleep

and on the behavior of attention levels of two administrative workers, making use of a low-cost brain computer interface (BCI) to capture encephalographic signals of attention and a smart watch to sense physical activity and sleep quality.

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Materials and methods

An experimental research with a mixed approach was developed, proposing a case study in a convenience sample of two administrative engineers (a man and a woman) who participated voluntarily and were selected taking into account particular aspects of their personal and work lives, such as: they have been working at the company for about 3 years, they have a grueling workday of 9 to 10 hours a day from Monday to Friday and sporadically on Saturdays, they live with their parents, they study a postgraduate course at a distance, they have a partner, they

go to bed around 11:00 p.m. at night, wake up between 5:30 – 6:00 a.m. and finally, they are considered sedentary people since they do not regularly perform physical activity and the number of average daily steps for work activities is 7,500 for men and 5,500 for women.

The case study was developed during a working month (not counting weekends), where each of the workers recorded the variables of sleep quality and physical activity for 24 hours, using the Huawei GT smart watch as a technological instrument. 2 - 46mm (Figure 1), which has a group of sensors, such as the optical one to estimate heart rate, the biometric or oximeter to detect oxygen saturation in the blood, and the three-axis accelerometer to detect movement of the user, which, in conjunction with the Trusleep technology, allowed to monitor the sleep cycle and quality (amount of night sleep, data on deep sleep, light sleep, REM sleep, sleep score, times of awakening and naps) and activity physics, as presented in Figure 1. These technological tools have been used for various health [24], [25] and sport [26] research.

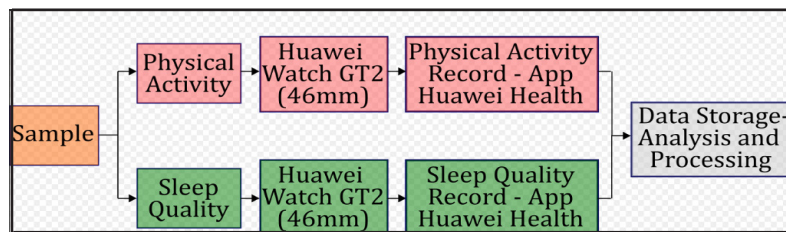


Figure 1. Record of physical activity and quality of sleep – Workers

The attention of the workers was evaluated through the attentional d2 test, which was configured in random mode with the MenPas psychosocial evaluation platform [27] and through the BCI MindWave Mobile II headband from the firm NeuroSky [28], [29], which is a portable device for detecting brain waves (alpha, beta, delta, gamma and theta waves) capable of safely emitting and measuring electroencephalographic (EEG) power spectra, using ThinkGear biosensors [30], as presented in Figure 2

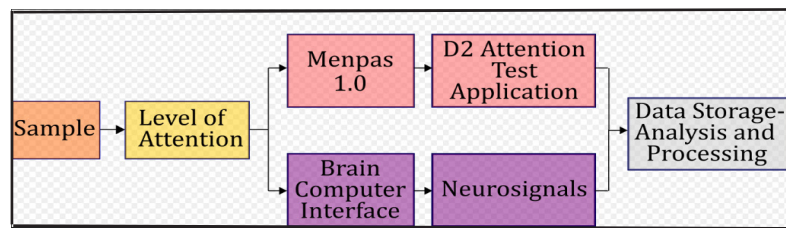


Figure 2. Record of attention levels – Workers

As a particularity of the study, both the female worker and the male worker performed extra-work physical activity (running outdoors), for a week from Monday to Friday, at an interval of approximately 45 minutes, after the workday (7:30 - 8: 30 p.m.), and it was compared with a regular routine week, performing the following data processing.

Analysis of physical activity on sleep quality

- a. Tabulation of the data corresponding to the sleep quality variables (number of hours of sleep, score, quantity and percentage; of deep sleep, light sleep and REM sleep) taking into account the date and worker. For a total of 160 data (80 per worker).
- b. Grouping of data according to day and week of physical and not physical activity.

- c. Construction of graphs of the number of hours of sleep, score obtained in the quality of sleep and the behavior of the sleep phases of each worker, taking into account whether or not they performed physical activity.
- d. Statistical analysis (averages, differences, quantitative and qualitative comparison) and discussion of results.
- b. Organization of the data taking into account the date and time of execution of the test, interval (5 minutes) where each worker used the headband (MindWave) getting a total of 100 average service records (50 records for each worker).
- c. Grouping and calculation of the average attention by day of the week (Monday – Friday) in order to obtain a representative value of average attention per day.

Analysis of physical activity on attention - d2 attentional test

- a. Tabulation in a spreadsheet of the variables of the d2 Test (TA, TR, O, C, TOT, CON) obtained through the MenPas platform, which was applied to each worker once a day (Figure 9). For a total of 1680 records (840 for each worker).
- b. Calculation of the maximum score that each worker could obtain by variable and by the test in general.
- c. Calculation of the effectiveness (Points obtained*100 / Maximum points) of execution obtained for each variable of the Test
- d. Grouping and classification of the effectiveness results according to the days in which the workers carried out or not physical activity.
- e. Statistical analysis of the effectiveness obtained per worker, according to the test variables and taking into account whether or not the worker performed physical activity.
- f. Discussion of the results

Results and discussion

Influence of physical activity on sleep quality

Figures 3 and 4 present the comparison of the number of hours of sleep recorded by each of the workers (man and woman) during the week that they performed physical activity (blue color) and during the week that they did not (orange color). where it can be seen that the week in which they did not perform physical activity, had a greater number of hours of sleep compared to the week in which they did physical activity, with an average difference in the week of approximately 58 min for the female worker and 24 min for the male worker.

Analysis of physical activity on attention – BCI MindWave Mobile II

- a. Obtaining the .csv file generated by the EEG Reader application.

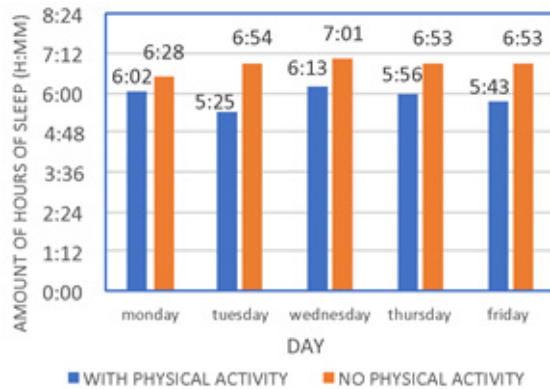


Figure 3. Number of hours of sleep - female worker

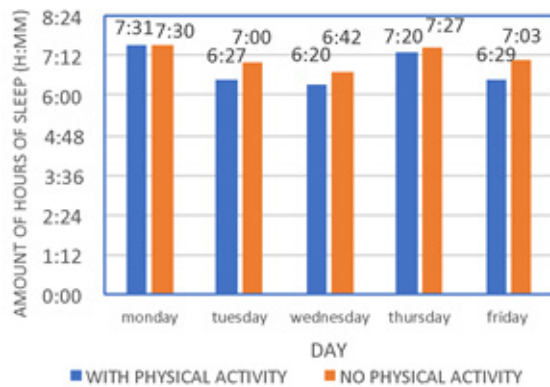


Figure 4. Number of hours of sleep – male worker

Figures 5 and 6 show the comparison and recorded score of sleep quality in the study period (with and without physical activity) of the workers, where it can be seen:

So that the case of the female worker; that the score on Monday, Wednesday and Thursday (84,82,81) are higher in the week in which physical activity was carried out, with the average difference of these days being 4 points, while on Tuesday and Friday, the score is higher on days without physical activity (78,74), with an average difference of 3 points; therefore, it can be concluded that physical activity positively influences sleep quality, since, despite the fact that the female worker had fewer hours of sleep (Figure 3) in the week that she did physical activity, she obtained a better sleep quality score on 3 of the 5 days, compared to the week that she did not do physical activity. In the case of the male worker; that the sleep score from Monday to Thursday (84,79,82,81) was greater or equal in the week that he/she did physical activity, compared to the week that he/she did not (77,79,80,81), despite that on these days the male worker recorded less sleep time (Figure 4); therefore, it can be said that physical activity positively influenced sleep quality, because with less sleep time, the recorded score is higher (Figure 6).

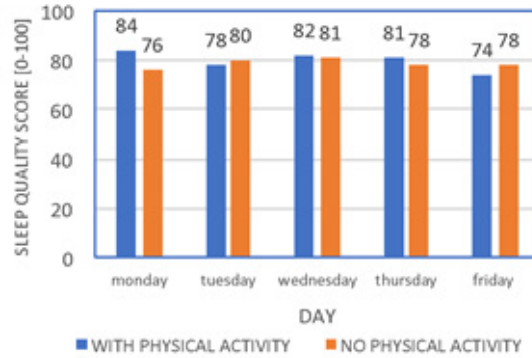


Figure 5. Sleep quality score – Female worker

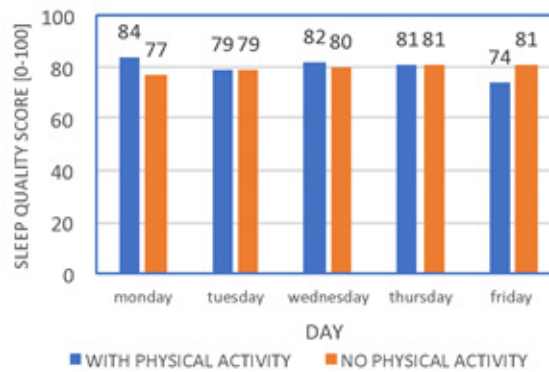


Figure 6. Sleep quality score – Male worker

Figures 7 and 8 present the comparison of the percentages registered by the workers in the deep sleep phase, which corresponds to the most effective phase of sleep to eliminate tiredness and recover energy, the light sleep phase, which is the easiest stage to wake up because the senses are active, and the REM sleep phase, where the muscles are usually paralyzed and the person usually “dreams” [31]. As a result of the comparison, it is evident that:

In the case of the female worker (Figure 7), the percentages of deep sleep in the week with physical activity are in a range of 34%-41%, being higher than the week in which no physical activity was performed, which are in a range of 24%-33%, indicating that considering that the two ranges are within the reference parameters of 20% to 60%, physical activity allows obtaining higher percentages in deep sleep and better sleep quality.

Likewise, the percentages of REM sleep are higher with a range of 14%-28% in the week with physical activity, while in the week without physical activity the range was 8%-18%, which are outside the reference percentages, denoting that it is possible to obtain more REM sleep time when physical activity is performed, and thus maintain mental well-being and reduce stress.

Finally, it can be observed that the percentages registered in the light sleep phase are less than 46% on the days in which the female worker performed physical activity, being within the normal reference of <55%, while the percentages on the days without physical activity exceed the normal reference, with percentages up to 59%, this means that light sleep is reduced by doing physical activity.

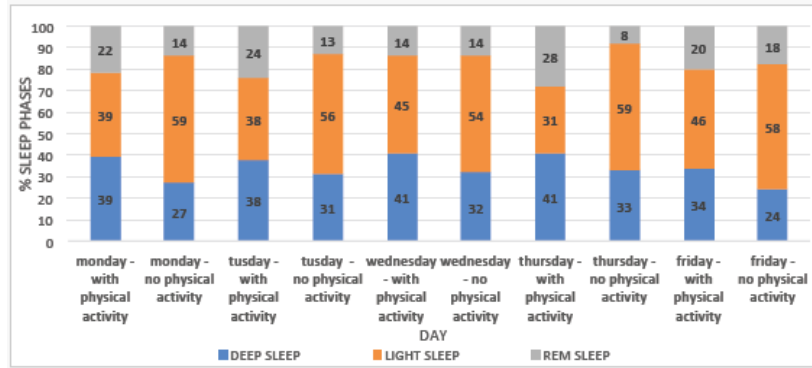


Figure 7. Percentages of sleep phases - female worker

In the case of the male worker (Figure 8), the percentages of the sleep phases show that deep sleep is in a range of 26%-34% in the week with physical activity, being within the normal reference (20% - 60%), while the range of the week without physical activity is 9% - 37%, which is below the regular percentages. On the other hand, the range of REM sleep percentages is 4%-27% in the week with physical activity, and 7%-28% in the week without physical activity, indicating that it is outside the reference percentages. (10% - 30%) only on Tuesdays and that the maximum percentages of REM sleep of the male worker are similar both in the week in which they performed physical activity, and in the week in which they did not.

Finally, the percentages registered in the light sleep phase are less than 68% when the male worker performs physical activity, and less than 77% when he does not perform physical activity, indicating that physical activity promotes a longer recovery time or deep sleep.

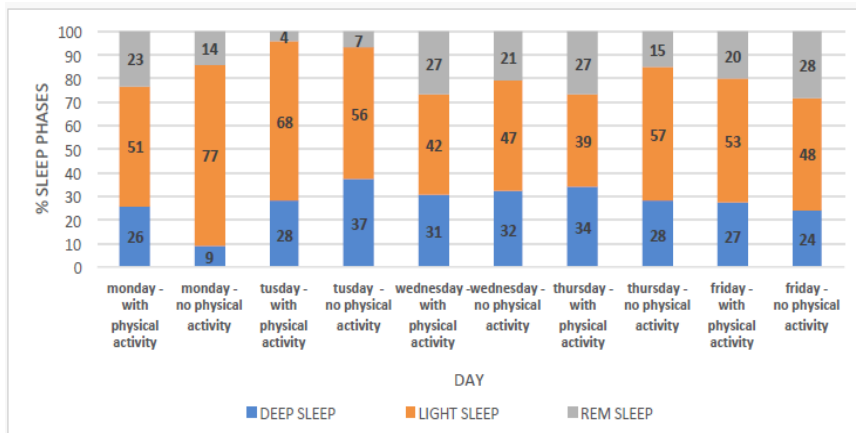


Figure 8. Percentages sleep phases – male worker

Influence of physical activity on attention levels

Table I and Figure 9 present the comparison of the effectiveness percentages achieved by the administrative engineer for each variable of the d2 Attentional Test, where it can be observed that the week that she developed physical activity, she reached average intervals higher than the effectiveness achieved in the week without physical activity, highlighting an improvement of 0.36% and 1.16% in the variables of motivation (TA) and precision (TR) respectively.

Table I. Development effectiveness Test d2 – female worker

Description	Day	Effectiveness [%]					
		(TR)	(TA)	(O)	(C)	(TOT)	(CON)
Week with physical activity	monday	98,45	95,68	96,24	100	97,59	95,68
	tuesday	99,17	97,33	97,95	100	98,68	97,33
	wednesday	97,48	95,39	98,62	99,66	96,81	94,08
	thursday	96,20	92,36	95,17	100	95,04	92,36
	friday	96,94	96,58	99,29	100	96,78	96,58
	Average	97,65	95,47	97,45	99,93	96,98	95,21
Week without physical activity	monday	97,85	90,78	92,19	100	96,20	90,78
	tuesday	98,73	98,68	97,99	100	98,26	98,68
	wednesday	95,89	93,29	95,68	100	94,91	93,29
	thursday	97,84	96,30	96,92	100	97,18	96,30
	friday	96,19	92,75	95,31	100	95,19	92,75
	Average	97,30	94,36	95,62	100	96,35	94,36

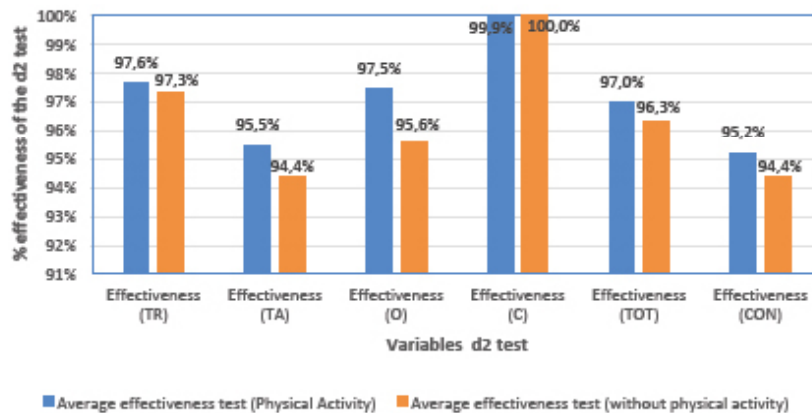


Figure 9. Average effectiveness of d2 Test variables – female worker

Likewise, Table II and Figure 10 present the effectiveness of the scores obtained by the male worker in the development of the Test during the study period, allowing us to appreciate that there is an improvement in the effectiveness of the execution of the d2 Test when performing physical activity, highlighting an improvement in the motivation and precision variables (TA and TR) of 0.26% and 5.14 % respectively.

Table II. Effectiveness development Test d2 – male worker

Description	Day	Effectiveness [%]					
		(TR)	(TA)	(O)	(C)	(TOT)	(CON)
Week with physical activity	monday	91,21	86,33	97,50	100	86,94	86,33
	tuesday	98,99	92,42	92,62	100	97,48	92,42
	wednesday	95,65	91,52	96,69	100	94,84	91,52
	thursday	96,45	80,20	97,07	100	86,50	80,20
	friday	96,04	92,55	95,97	99,83	94,88	91,93
	Average	95,67	88,60	95,97	99,97	92,13	88,48
Week without physical activity	monday	92,42	75,00	80,83	100	88,63	75,00
	tuesday	93,78	79,05	83,76	100	90,75	79,05
	wednesday	97,94	90,51	95,10	100	96,83	90,51
	thursday	99,17	89,47	90,76	100	97,33	89,47
	friday	93,79	86,21	92,00	100	92,11	86,21
	Average	95,42	84,05	88,49	100	93,13	84,05

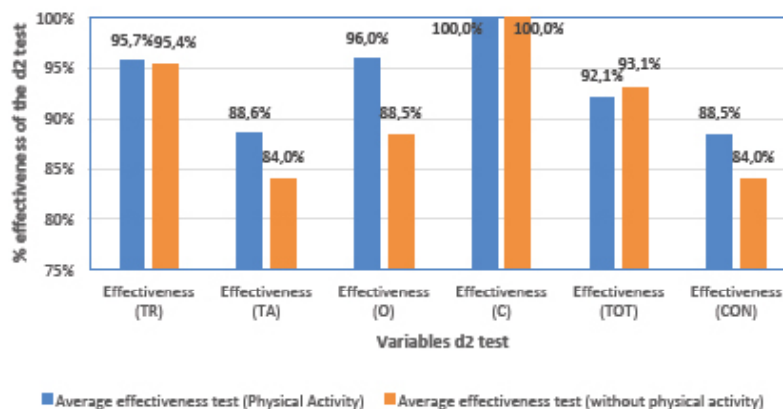


Figure 10. Average effectiveness of d2 Test variables – male worker

The encephalographic signals (EEG) of average attention per working day during the development of the Test, are presented in Tables III and IV and Figures 11 and 12, where a significant improvement can be detailed when the workers performed physical activity, specifically in four of the five days a week in the case of the female worker and on three of the five days in the case of the male worker.

Table III. Average values of attention EEG signals performing Test d2 – female worker

Day	Week with physical activity	Week without physical activity
Monday	63,20	47,25
Tuesday	62,60	45,67
Wednesday	47,00	63,75
Thursday	65,40	47,00
Friday	67,75	37,33

Table IV. Average values of attention EEG signals performing Test d2 – male worker

Day	Week with physical activity	Week without physical activity
Monday	69,40	63,80
Tuesday	49,80	66,20
Wednesday	70,6	60,25
Thursday	62,40	56,60
Friday	64,60	61,60

When analyzing the attention behavior of the female worker during the study period, it can be seen that only during the week that she performed physical activity, she was able to reach slightly high scores of attention [60-80). On the other hand, in the week that she did not perform physical activity, her attention remained at standard scores [40-60), according to the Neurosky classification, which allows us to suggest physical activity as a good practice, to achieve higher levels of attention.

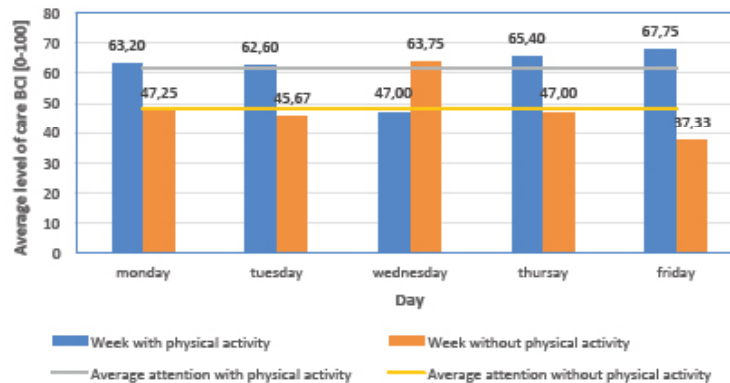


Figure 11. NeuroSky care levels –female worker

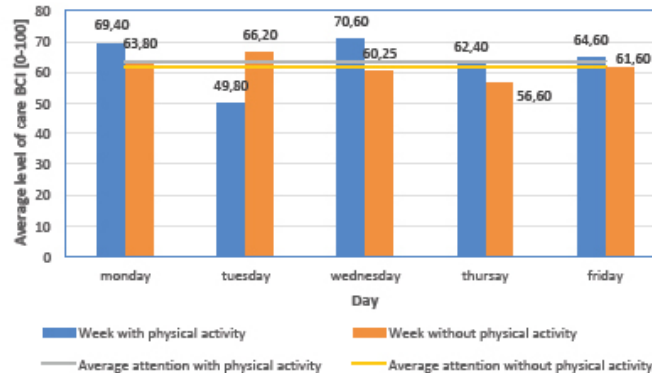


Figure 12. NeuroSky care levels – male worker

In the same way, in the case of the male worker, it can be observed that, although he obtained slightly high scores of attention during most (80% of the study period) of the days (with and without physical activity), there was a slight improvement in the average attention level (63.36 vs 61.69) in the week in which the male worker performed physical activity and it was precisely there, where he achieved the highest average record (70.6) of his entire study period.

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Conclusions

The biweekly data (with and without physical activity) of each worker’s sleep

made it possible to show that physical activity positively impacts the quality of sleep, given that, despite recording a number of hours of sleep similar to the usual (6-7h), the percentage of deep sleep was higher when performing physical activity, achieving better rest and sleep quality in the workers.

When evaluating the attentional behavior of the workers, both with the d2 test and with the encephalographic signals (EEG), it can be seen that approximately in 80% of the cases, they had an improvement in the level of attention when performing physical activity, reason why which is recommended to include extra-work physical activity within the daily chore, routine or good practice of the workers

For future research, it is recommended to continue using technological tools such as neurotechnology to validate the influence of physical activity on different emotional variables such as joy, stress, motivation, interest, commitment, relaxation, among others, and thus generate inputs for applications on different topics in education, computing, marketing, quality of life, among others.

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