DOI: 10.1590/1809-2950/16768425012018

Does the wearing time of motion sensor interfere with the choice of physical activity in daily life outcomes of COPD patients?

O tempo de uso do sensor de movimento interfere na escolha do desfecho de atividade física na vida diária em pacientes com DPOC?

El tiempo de uso del sensor de movimiento interfiere en la escoja del resultado de actividad física en la vida diaria en pacientes con EPOC?

Lorena Paltanin Schneider[1], Karina Couto Furlanetto[1,2], Nidia Aparecida Hernandes[1], Fabio Pitta[1]

ABSTRACT | This study analyzes physical activity in the daily lives (PADL) of patients with chronic obstructive pulmonary disease (COPD), measured in three different periods of daily use of motor sensor: 8 hours, 12 hours, and awake time, in order to identify if the PADL outcomes are different among each other. It is a transversal study with 45 patients (66±8 years) classified as having moderate to severe COPD. The PADL was assessed using the physical activity monitor SenseWear Armband (SAB) for 7 consecutive days, 24 hours a day. The PADL results provided by the monitor in the three evaluation periods within 24 hours of use were compared. The sedentary and physical activity outcomes (number of steps and total energy expenditure) were different in the three periods using the SAB, having higher values in the assessment per awake time. Regarding the physical activity outcomes divided into age groups – 3 or 2 metabolic equivalents (METs) –, the outcomes were similar to the evaluation for 12 hours and per awake time. It was concluded, thus, that the use of physical activity monitor during the awake time is the most indicated outcome for accurate and complete monitoring of sedentarism and physical activity in COPD patients.

Keywords | Chronic Obstructive Pulmonary Disease; Motor Activity; Accelerometry.

RESUMO | Este estudo analisa a atividade física na vida diária (AFVD) de pacientes com doença pulmonar obstrutiva crônica (DPOC), quantificada em três diferentes períodos de uso diário do sensor de movimento: 8 horas, 12 horas e período de tempo acordado, a fim de identificar se os desfechos de AFVD diferem entre si. Trata-se de um estudo transversal com 45 pacientes (66±8 anos) classificados com DPOC de moderada a grave. A AFVD foi avaliada utilizando-se o monitor de atividade física *SenseWear Armband* (SAB) durante 7 dias consecutivos, 24 horas por dia. Compararam-se os resultados de AFVD fornecidos pelo monitor nos três períodos de avaliação dentro das 24 horas de uso. Os desfechos de sedentarismo e de atividade física (número de passos e gasto energético total) foram diferentes nos três períodos de utilização do SAB, com maiores valores na avaliação por período de tempo acordado. Quanto aos desfechos de atividade física estratificados por idade – 3 ou 2 equivalentes metabólicos (MET) –, os resultados foram similares na avaliação por 12 horas e por período de tempo acordado. Concluiu-se, afinal, que o uso do monitor de atividade física durante o tempo acordado é o desfecho mais indicado para monitoração acurada e completa de sedentarismo e atividade física em pacientes com DPOC.

Descritores | Doença Pulmonar Obstrutiva Crônica; Atividade Motora; Acelerometria.

Study presented as a poster in the XVIII International Symposium of Cardiorespiratory Physical Therapy and Intensive Care Physical Therapy, from June 8th to 10th, 2016, Belo Horizonte (MG), Brazil.

[1] Laboratório de Pesquisa em Fisioterapia Pulmonar (LFIP), Department of Physical Therapy, Universidade Estadual de Londrina (UEL) – Londrina (PR), Brazil.

[2] Centro de Pesquisa em Ciências da Saúde, Universidade Norte do Paraná (Unopar) – Londrina (PR), Brazil.

Corresponding address: Fabio Pitta – Hospital Universitário Regional Norte do Paraná, Departamento de Fisioterapia – Avenida Robert Koch, 60, Vila Operária, Londrina (PR), Brazil – Zip Code: 86038440 – Telephone: (43) 3371-2477 – E-mail: fabiopitta@uol.com.br – Finance source: Nothing to declare – Conflict of interests: Nothing to declare – Presentation: Aug. 23th, 2016 – Accepted for publication: Jan. 15th, 2017 – Approved by UEL's Research Ethics Committee under the statement no. 123/09.

RESUMEN | Este estudio analiza la actividad física en la vida diaria (AFVD) de pacientes con enfermedad pulmonar obstructiva crónica (EPOC), cuantificada en tres distintos períodos de uso diario del sensor de movimiento: 8 horas, 12 horas y el período de tiempo despierto, con la finalidad de identificar si los resultados de AFVD difieren entre sí. Se trata de un estudio transversal con 45 pacientes (66±8 años) clasificados con EPOC de moderada a grave. La AFVD ha sido evaluada con la utilización del monitor de actividad física SenseWear Armband® (SAB) durante 7 días consecutivos, las 24 horas del día. Se han comparado los resultados de AFVD suministrados por el monitor en los tres períodos de evaluación dentro de las 24 horas de uso. Los resultados de sedentarismo y de actividad física (el número de pasos y de gasto energético total) han sido distintos en los tres períodos de utilización del SAB, con valores más grandes en la evaluación por período de tiempo despierto. Cuanto a los resultados de la actividad física estratificadas por edad – 3 o 2 equivalentes metabólicos (METs) –, los resultados han sido similares en la evaluación por 12 horas y por el período de tiempo despierto. Se ha concluido, por fin, que el uso del monitor de la actividad física durante el tiempo despierto es el resultado más indicado para el monitoreo preciso y completo de sedentarismo y de la actividad física en pacientes con EPOC.

Palabras clave | Enfermedad Pulmonar Obstructiva Crónica; Actividad Motora; Acelerometría.

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a significant and growing cause of mortality and morbidity around the world[1]. Besides obstructing the airflow, COPD is also characterized by deconditioning and physical inactivity[2,3], among other characteristics.

There are, in literature, many ways of measuring physical activity in the daily lives of COPD patients, such as questionnaires and motion sensors. Despite the use of questionnaires for measuring physical activity having been common in scientific literature[4], its inaccuracy, especially when used individually, has encouraged researchers and clinic professionals to look for viable options for objective monitoring, such as motion sensors. The main kinds of motion sensors are the pedometers and accelerometers. Despite its convenience and low cost, the use of pedometers can cause the underestimation of physical activity assessment in populations who walk slowly, as happens to COPD patients[4-6]. On the other hand, accelerometers are technologically advanced and more accurate motion sensors, which register not only the number of movement done, but also its intensity. These devices provide the estimation of energy expenditure in different physical activity intensities, and some of them are developed technologically in order to also provide the time spent in different activities and postures by the individual[3,7,8].

SenseWear Armband and Dynaport Minimod, for example, are some of the physical activity monitors validated for COPD population and frequently used in the current literature[5,7-9]. According to the monitor used, it is possible to choose different outcomes to measure physical activity as, for example, total energy expenditure, energy expenditure during physical activity, time lying down, number of steps, time in activity, sedentary time, and the mean of metabolic equivalents (METs) spent in the period. Through these outcomes, it is possible to analyze how much is the individual physically active or inactive in his/her daily life. However, there is no consensus about which of the outcomes better reflects the level of physical activity of a population. Usually, the choice of which outcome is used to measure physical activity is made by the researchers involved in each study and, surely, more comparative studies are needed to complement the current literature so that the best outcome(s) can be defined.

Besides choosing the outcome to measure physical activity, other assessment characteristics still need to be deeply studied. More recently, a standardization of physical activity analysis was proposed[10] – the patient should be evaluated for at least 4 days, also suggesting that the sunlight duration should be taken into account in the analysis. This study also recommends the physical activity monitor should be used for at least 8 hours a day by the individual. However, various scientific studies available have used different monitor wearing time periods for evaluating physical activity as, for example, 12 hours a day, 24 hours a day, and the whole time the individual is awake per day[11-13]. Recent studies have assessed physical activity during the awake time and concluded that the longest physical

activity periods occur during the morning and at the beginning of the afternoon, suggesting, then, that the time after the period when the individual is awake does not need to be evaluated, since there is no significant increase in physical activity during this period[13,14]. Despite that, it is still unknown if the physical activity monitor wearing time interferes on the choice of the physical activity outcomes.

Therefore, the aim of this study was to compare the physical activity of COPD patients measured in three different daily periods of physical activity monitor use (8 hours/day, 12 hours/day and during the whole time awake/day), and to identify if there are differences in each physical activity outcome (total energy expenditure, energy expenditure during activity, number of steps, active time, and sedentary time) by comparing these three daily periods of monitor use.

METHODOLOGY

The study was performed in the Laboratório de Pesquisa em Fisioterapia Pulmonar (LFIP) (Research Lab in Pulmonary Physical Therapy) at the Regional University Hospital of the North of Paraná (HURNP) in Londrina-PR, Brazil. All patients included in the study signed an informed consent form, which is the same of a project of longitudinal research to which this subproject is connected. The longitudinal project was approved by the Committee of Ethics in Research of Universidade Estadual de Londrina, under the statement no. 123/09.

In this transversal study with convenience sample, 45 individuals with COPD diagnosis according to international guidelines[1] were included, who did not present severe limitations to perform physical activities in daily life at the beginning of the evaluations and who did not have done physical exercises regularly in the last year. The individuals who did not properly fulfilled the evaluation days according to what was proposed would be excluded, as well as those who presented limiting neural and musculoskeletal complications or exacerbations during the assessment period. The study's sample was comprised by COPD patients who were in initial assessment previous to their participation in the longitudinal research project aforementioned, which involved the performance of different kinds of physical training.

The participants were submitted to the evaluation of physical activity level in daily life through the physical activity monitor SenseWear Armband (Body Media, United States) [SAB], previously validated for COPD patients[5,7,8]. The participants used the multi-sensor for 7 consecutive days of the week, 24 hours a day.

SAB is a small and light multi-sensor, wore in the right upper arm area (brachial triceps muscle area). It is composed by a biaxial accelerometer connected to physiological sensor and it estimates daily energy expenditure through algorithms developed by the manufacturer. The main outcomes provided by SAB are the total energy expenditure, energy expenditure during activity, number of steps, mean of metabolic equivalents, and the time spent in different physical activity intensities (sedentary, moderate, vigorous and very vigorous). A final report is obtained by data analysis using the software that comes with the monitor (Inner View)[5,15,16].

All the PADL outcomes provided by the monitor in the three periods of patient assessments and within the 24 hours of used were compared, specifically: 8 hours and 12 hours counted from the moment the individual woke up, and the time between the moment the individual woke up and when the individual went to sleep (awake time).

The analysis of data distribution was performed by the Shapiro-Wilk test. If the data presented normal distribution, they would be described as mean ± standard deviation and compared by repeated measures variance of analysis (ANOVA). If they had non-normal distribution, the data would be described as mean [25-75% interquartile range] and the Friedman test was performed for comparison. Data tabulation was performed by the software Microsoft Excel and the statistical analysis by the software GraphPad Prism 6.0. Statistical significance was determined as $p<0.05$.

OUTCOMES

Fourty-five participants were included, aging about 66 years old and having moderate to severe obstruction levels. General characteristics of the individuals participating in the study are described in Table 1. The average awake time was 889.6 [849.2 – 923.1] minutes, that is, about 14h49min.

Table 1. Characteristics of the study's participants

N	45
Gender (M/F)	25/20
Age (years)	66±8
BMI (kg/m²)	26±6
FEV1 (%)	46±20
FEV1/FVC (%)	69 [55-83]

BMI: Body mass index; FEV1: forced expiratory volume in 1 second; FEV1/FVC: ratio between forced expiratory volume in 1 second and the forced vital capacity.

The results of the comparison of outcomes provided by SAB are described in Table 2. When the three periods were compared, all sedentary outcomes showed higher values when evaluated during AP. These outcomes were: time lying down, sedentary time classified by age, sedentary time lower than 3 METs, sedentary time lower than 2 METs, and sedentary time lower than 1.5 METs.

Table 2. Comparison among the variables of physical activity in daily life (PADL) in the three daily periods of device use

VARIABLES PADL	8 HOURS	12 HOURS	PERIOD AWAKE
TEE (kcal)	865 [726-1029]	1261 [1052-1514]*	1515 [1231-1743]*,**
STEPS/DAY	5041 [2434-6556]	6248 [3756-8829]*	6880 [4019-9558]*,**
T. LYING DOWN (min)	24,2 [12,1-17,2]	37,2 [12,9-62]*	56,9 [67-159,3]*,**
MEAN METS (MET)	1,7 [1,4-1,9]	1,7 [1,3-1,9]*	1,6 [1,3-1,8]*
EEA>AGE (kcal)	92,5 [25-136]	111 [34,4-200,4]*	123 [47,8-205]*
PAD>AGE (min)	18 [5,1-37]	22 [9-47]*	23,9 [10,1-49,2]*
SED.T.AGE (min)	462 [443,1-474,9]	698 [673-711]*	855,7 [791,7-900,3]*,**
MOD.T.AGE (min)	16,7 [4,6-31,3]	22[8,3-46,7]*	23[10-50,9]*
VIG.T.AGE (min)	0,2 [0-3,4]	0,2 [0-4,4]	0,7 [0-4,7]*
V.VIG.T.AGE (min)	0 [0-0]	0 [0-0]	0 [0-0]
EEA>3 (kcal)	145,6 [87,6-283]	200 [112,5-432]*	228,6 [128-448]*
PAD>3 (min)	38,4 [20,8-73,3]	49,3 [25,9-101,4]*	54 [27,8-108,1]*
INACT<3 (min)	441,6 [406,7-459,2]	670,7 [618,6-694,2]*	806,4 [764,2-860,6]*,**
MOD.T>3 (min)	38,2 [20,8-72,4]	49,3 [25,7-100]*	54 [27,8-106,7]*
VIG.T>6 (min)	0[0-0,7]	0 [0-1]	1,4 [0-11,4]*
V.VIG.T>9 (min)	0[0-0]	0 [0-0]	0 [0-0]
PAD>2 (kcal)	8889 [6244-13680]	13740 [8057-17880]*	15883 [9219-19791]*
SED.T<2 (min)	331,9 [252-375,9]	491 [422-585,7]*	633,2 [565,3-711,1]*,**
PAD>1,5 (min)	203,2 [157,3-260,7]	296 [211,9-358,3]*	331,6 [244,9-401,6]*,**
SED.T<1,5 (min)	276,9 [219,3-321,8]	424 [361,7-507,3]*	569,2 [483,9-633,2]*,**

*p<0,05 versus 8 hours. **p<0,05 versus 12 hours. Kcal: kilocalories; min: minutes; MET: metabolic equivalent; GET: total energy expenditure; STEPS: number of steps; LYING DOWN: period lying down; MEAN METS: METs' mean; EEA>AGE: energy expenditure during activity; PAD>AGE: physical activity duration classified per age; SED.AGE: sedentary activity classified per age; MOD.AGE: moderate activity duration classified per age; VIG.AGE: vigorous activity duration classified per age; V.VIG.AGE: very vigorous activity duration classified per age; EEA>3: energy expenditure during activity classified as higher than 3 METs; PAD>3: duration of physical activity classified as higher than 3 METs; INACT<3: inactive period smaller than 3 METs; MOD>3: duration of moderate activity higher than 3 METs; VIG>6: duration of vigorous activity higher than 6 METs; V.VIG>9: duration of very vigorous activity higher than 9 METs; PAD>2: duration of activity higher than 2 METs; SED<2: duration of sedentary activity smaller than 2 METs; PAD>1,5: duration of activity higher than 1,5 METs; SED<1,5: duration of sedentary activity smaller than 1,5 METs.

Likewise, the physical activity outcomes regarding the number of steps per day and total energy expenditure were different from each other during the three periods with the monitor, given that the awake time has also showed the highest values (Table 2). Among the PADL outcomes divided by 3 or 2 METs or by age, there was no statistically significant difference between the assessment performed for 12 hours and during the awake time, as well as the average METs. The outcome of time spent in very vigorous physical activity did not show statistically significant differences when the three periods with the monitor were compared.

DISCUSSION

This study's main results have showed that sedentary outcomes, as well as certain physical activities outcomes (number of steps and total energy expenditure) were different when the three periods were compared, given that the awake time showed the highest values. In addition, when the physical activity outcomes were divided into 3 or 2 METs or by age of the patients, as well as the METs average, they did not show any differences when compared between 12 hours of use or during the awake time.

The results suggest that, overall, the awake time reveals more completely the individuals' sedentarism and physical activity, showing exactly how much time do they effectively spend performing mild, moderate and vigorous activities, or in sedentary time. In most of this study's outcomes, the 8-hour, and even the 12-hour evaluations, showed lower values then the awake time, suggesting that the assessment for 8 and 12 hours possibly underestimates the results of a large share of outcomes when compared to the awake time, given that the evaluation in the awake time (an average of 14 hours and 49 minutes) is considerably longer than 8 hours and 12 hours. This is the first study that suggests the superiority of the assessment in the awake time as an outcome of physical activity monitoring in COPD patients.

According to the recent literature, it is known that the number of days and wearing time are factors that can interfere with the reliability of the assessment of physical activity (PA)[13,17]. Recent studies show that, for transversal analysis, 2 to 3 days are enough for reliable PA measures in patients classified as GOLD IV, as well as 5 days are necessary for GOLD I patients[12]. While for longitudinal shifts, 4 days of evaluation have proved to be enough to demonstrate effects of consecutive treatments for pulmonary rehabilitation in moderate to severe COPD, given that weekends are excluded from the analyses[10]. However, there are still doubts about how much time per day should the accelerometer be used for a reliable assessment. Some studies have shown that a 24-hour use can characterize the patient's day as a whole, while others say that an 8-hour or 12-hour period per day is enough to gather most of the individual's day, besides those who affirm that considering the sunlight period in the day significantly influences changes in physical activities[10].

The outcomes that showed the number of steps and total energy expenditure, as being different in the three periods wearing the monitor, while other analyzed physical activity outcomes did not show differences between the 12-hour period and the awake time, confirm the results of another study that discusses the difference between PA quantity and quality in COPD patients. This study concluded that, for COPD patients, the mere increase in low intensity physical activity can cause benefits[18]. Thus, it is understood that the number of steps and energy expenditure made by the individuals are not essential for evidencing benefits to health, while the fact of reducing sedentary activities and increasing low intensity activities are enough for this objective.

The threshold for defining an activity as very vigorous is considered very high (higher or equal to 8.8 METs). This makes patients spend very little time in very vigorous activities, regardless of how many hours are evaluated, which can explain the fact that this outcome had similar values in all three periods wearing the monitor[19]. The American College of Sports Medicine (ACSM) considers sedentary activities all those performed below 3 METs; however, this is a controversial issue in the current literature. There are different values proposed in literature, as 1.5 or 2 METs, thus reducing the time spent in activities in which the patient is considered sedentary or active[19,20].

Some limitations and strong points of this study can be highlighted. The study was performed with a convenience, and relatively small, sample; studies with bigger samples can, in the future, confirm these results. Moreover, the sample was comprised by patients classified as moderate to severe GOLD and, thus, at this moment, the results of this study still cannot be extended to mild stages of the disease. Lastly, the sunlight period was not assessed in the physical activity evaluation, and thus it was not possible to know if this variable interferes with the analyzed periods. Methodologically speaking, this study's main strengths are related to: 1) the use of accelerometer for 7 consecutive days in the week, given that the more days evaluated, the more accurate will be the analysis; and 2) a physical activity monitor validated and demonstrably accurate for COPD population was used[9,21].

CONCLUSION

In different physical activity and sedentary outcomes, the PADL evaluation considering the awake time per day showed higher values than the 8-hour, and even 12-hour, evaluations. This result suggests that the 8 or 12-hour assessment possibly underestimates the results of these outcomes. Thus, wearing the physical activity monitor during the whole awake time is the most suitable outcome for an accurate and complete monitoring of sedentarism and physical activity for COPD patients.

REFERENCES

1. Global Initiative for Chronic Obstructive Lung Disease. Global Strategy for the diagnosis, management and prevention of COPD, global initiative for Chronic Obstructive Lung Disease (GOLD) [homepage in the Internet]. [unknown place]: Crux Creative; 2016 [quoted on 2018 feb 6]. Available from: <https://goo.gl/UDxdED>.
2. Oga T, Nishimura K, Tsukino M, Sato S, Hajiro T. Analysis of the factors related to mortality in chronic obstructive pulmonary disease: role of exercise capacity and health status. Am J Respir Crit Care Med. 2003;167(4):544-9. doi: 10.1164/rccm.200206-583OC
3. Pitta F, Troosters T, Spruit MA, Probst VS, Decramer M, Gosselink R. Characteristics of physical activities in daily life in chronic obstructive pulmonary disease. Am J Respir Crit Care Med. 2005;171(9):972-7. doi: 10.1164/rccm.200407-855OC
4. Pitta F, Troosters T, Probst VS, Spruit MA, Decramer M, Gosselink R. Quantifying physical activity in daily life with questionnaires and motion sensors in COPD. Eur Respir J. 2006;27(5):1040-55. doi: 10.1183/09031936.06.00064105
5. Cavalheri V, Donária L, Ferreira T, Finatti M, Camillo CA, Ramos EMC, et al. Energy expenditure during daily activities as measured by two motion sensors in patients with COPD. Lancet Respir Med. 2011;105(6):922-9. doi: 10.1016/j.rmed.2011.01.004
6. Furlanetto KC, Bisca GW, Oldemberg N, Sant'anna TJ, Morakami FK, Camillo CA, et al. Step counting and energy expenditure estimation in patients with chronic obstructive pulmonary disease and healthy elderly: accuracy of 2 motion sensors. Arch Phys Med Rehabil. 2010;91(2):261-7. doi: 10.1016/j.apmr.2009.10.024
7. Patel SA, Benzo RP, Slivka WA, Sciurba FC. Activity monitoring and energy expenditure in COPD patients: a validation study. Chronic Obstr Pulm Dis. 2007;4(2):107-12. doi: 10.1080/15412550701246658
8. Hill K, Dolmage TE, Woon L, Goldstein R, Brooks D. Measurement properties of the SenseWear armband in adults with chronic obstructive pulmonary disease. Thorax. 2010;65(6):486-91. doi: 10.1136/thx.2009.128702
9. Rabinovich RA, Louvaris Z, Raste Y, Langer D, van Remoortel H, Giavedoni S, et al. Validity of physical activity monitors during daily life in patients with COPD. Eur Respir J. 2013;42(5):1205-15. doi: 10.1183/09031936.00134312
10. Demeyer H, Burtin C, van Remoortel H, Hornikx M, Langer D, Decramer M, et al. Standardizing the analysis of physical activity in patients with COPD following a pulmonary rehabilitation program. Chest. 2014;146(2):318-27. doi: 10.1378/chest.13-1968
11. Pitta F, Troosters T, Probst VS, Langer D, Decramer M, Gosselink R. Are patients with COPD more active after pulmonary rehabilitation? Chest. 2008;134(2);273-80. doi: 10.1378/chest.07-2655
12. van Remoortel H, Camillo CA, Langer D, Hornikx M, Demeyer H, Burtin C, et al. Moderate intense physical activity depends on selected metabolic equivalent of task (MET) cut-off and type of data analysis. PLoS One. 2013;8(12):[9 p.]. doi: 10.1371/journal.pone.0084365
13. Watz H, Waschki B, Meyer T, Magnussen H. Physical activity in patients with COPD. Eur Respir J. 2009;33(2):262-72. doi: 10.1183/09031936.00024608
14. Mesquita R, Vanfleteren LE, Franssen FM, Sarv J, Taib Z, Groenen MT, et al. Objectively identified comorbidities in COPD: impact on pulmonary rehabilitation outcomes. Eur Respir J. 2015;46(2):545-8. doi: 10.1183/09031936.00026215
15. Jakicic JM, Marcus M , Gallagher KI , Randall C , Thomas E , Goss FL , et al. Evaluation of the SenseWear Pro Armband to assess energy expenditure during exercise. Med Sci Sports Exerc. 2004;36(5):897-904. doi: 10.1249/01.MSS.0000126805.32659.43
16. Tudor-Locke CE, Myers AM. Challenges and opportunities for measuring physical activity in sedentary adults. Sports Med Open. 2001;31(2):91-100. doi: 10.2165/00007256-200131020-00002
17. Hecht A, Ma S, Porszasz J, Casaburri R. Methodology for using long-term accelerometry monitoring to describe daily activity patterns in COPD. Chronic Obstr Pulm Dis. 2009;6(2):121-9. doi: 10.1080/15412550902755044
18. Donaire-Gonzales D, Gimeno-Santos E, Balcells E, Batlle J, Ramon MA, Rodriguez E, et al. Benefits of physical activity on COPD hospitalisation depend on intensity. Eur Respir J. 2015;46(5):1281-9. doi: 10.1183/13993003.01699-2014
19. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc. 2011;43(7):1334-59. doi: 10.1249/MSS.0b013e318213fefb
20. Hill K, Gardiner PA, Cavalheri V, Jenkins SC, Healy GN. Physical activity and sedentary behaviour: applying lessons to chronic obstructive pulmonary disease. Intern Med J. 2015:45(5):474-82. doi: 10.1111/imj.12570
21. van Remoortel H, Raste Y, Louvaris Z, Gianvedoni S, Burtin C, Langer D, et al. Validity of six activity monitors in chronic obstructive pulmonary disease: a comparison with indirect calorimetry. PLoS One 2012;7(6):[11 p.]. doi: 10.1371/journal.pone.0039198