Rev Bras Cineantropom Desempenho Hum

original article

https://doi.org/10.1590/1980-0037.2022v24e83854

Validation of the Trackhealth physical activity monitor

Validação do monitor de atividade física Trackhealth

Ricardo Ansaloni de Oliveira[1]
https ://orcid.org/0000-0002-2310-9047
Jeffer Eidi Sasaki[1]
https ://orcid.org/0000-0002-2083-4104
Natália Lujan Ferraz[1]
https ://orcid.org/0000-0002-4940-7958
Álvaro Ribeiro Gomes de Oliveira[2]
https ://orcid.org/0000-0002-5661-9692
Pedro Henrique Ataides de Moraes[3]
https ://orcid.org/0000-0002-6636-5518
Jair Sindra Virtuoso Júnior[1]
https ://orcid.org/0000-0001-7602-1789

Abstract – This is a quantitative methodological study for the validation of a research instrument. It aimed to validate the data from the TrackHealth accelerometry device. The sample consisted of 30 adult individuals of both sexes selected by convenience who met the inclusion and exclusion criteria. The physical activity monitors used for the research protocol were the ActiGraph® wGT3X-BT triaxial accelerometer and the TrackHealth accelerometer (TH). The activity protocol consisted of 4 (four) activities (walking at 4.8 and 6.4 km h[1] and running at 9.7 and 12 km h[1]) performed in the laboratory, on an Ibramed treadmill, lasting 5 (five) minutes at each stage. A difference was found between the raw acceleration data of the two devices, however the TrackHealth device showed higher sensitivity at speeds of 4.8 and 6.4 km/h, and a high level of agreement (2.7-2.8%) at the initial speeds of the magnitude vectors. However, there is still a need for improvement in the functioning of the device, so that TrackHealth can be commercialized.

Keywords: Comparison; Accelerometry; Motion; Raw data.

Resumo – *Trata-se de um estudo metodológico quantitativo para validação de um instrumento de pesquisa. O objetivo era validar os dados do dispositivo de acelerometria TrackHealth. A amostra foi composta por 30 indivíduos adultos de ambos os sexos selecionados por conveniência que atenderam aos critérios de inclusão e exclusão. Os monitores de atividade física utilizados para o protocolo de pesquisa foram o acelerômetro triaxial ActiGraph® wGT3X-BT e o acelerômetro TrackHealth (TH). O protocolo de atividades consistiu em 4 (quatro) atividades (caminhada a 4,8 e 6,4 km h[1] e corrida a 9,7 e 12 km h[1]) realizadas em laboratório, em esteira Ibramed, com duração de 5 (cinco) minutos em cada etapa. Foi encontrada uma diferença entre os dados brutos de aceleração dos dois dispositivos, no entanto, o dispositivo TrackHealth apresentou maior sensibilidade nas velocidades de 4,8 e 6,4 km / h, e um alto nível de concordância (2,7-2,8%) nas velocidades iniciais da magnitude vetores. Porém, ainda há necessidade de melhorias no funcionamento do aparelho, para que o TrackHealth possa ser comercializado.*

Palavras-chave: *Comparação; Acelerometria; Movimento; Dados brutos.*

1 Federal University of Triângulo Mineiro. Graduate Program in Physical Education. Uberaba, MG. Brazil.
2 Department of Electrical Engineering. Federal University of Triângulo Mineiro. Uberaba, MG. Brazil.
3 University Center of Goiatuba. Goiatuba, GO. Brazil.

Received: October 01, 2021
Accepted: November 17, 2021

How to cite this article: Oliveira RA, Sasaki JE, Ferraz NL, Oliveira ARG, Moraes PHA, Virtuoso Júnior JS. Validation of the Trackhealth physical activity monitor. Rev Bras Cineantropom Desempenho Hum 2022; 24:e83854. DOI: http://doi.org/10.1590/1980-0037.2022v24e83854

Corresponding author
Ricardo Ansaloni de Oliveira,
Graduate Program in Physical Education,
Federal University of Triângulo Mineiro
Av. Tutunas, 490, Tutunas, Uberaba (MG), Brazil.
E-mail: ricardo_ansaloni@hotmail.com.br

Copyright: This work is licensed under a Creative Commons Attribution 4.0 International License.

INTRODUCTION

The need to measure physical activity (PA) objectively and more accurately has become a reason for interest in epidemiology, given that the practice of PA is directly related to the health and disease process[1]. The use of accelerometry has grown in these studies as a way to objectively measure the variables, allowing greater reliability in the results obtained in the measurement of physical activity.

Accelerometers are capable of measuring the acceleration of a body indirectly through proprietary algorithms that perform the conversion of the signals generated, allowing us to estimate the intensity and frequency of PA practiced by the user[2].

Commercial accelerometers have been used to monitor PA and are able to measure objectively the number of steps taken and energy expenditure (EE) during a particular activity. These data outputs produce values in the form of accelerations or "activity counts" for given periods of time (e.g. counts/min^{-1}). According to the manufacturers, counts are the sum of the absolute values of accelerations in a specific period that represent the estimate of activity intensity measured within a specific time interval[3-4]. However, commercial accelerometers still have a high cost due to the need to import these devices, which makes it difficult to acquire a large number for application in large-scale studies.

Among the various types of accelerometers in the market, the ActiGraph® wGT3X has stood out for its wide use in studies[5]. This model was developed in 2009 by the company ActiGraph® and it was one of the first of its generation of accelerometers to measure acceleration in three axes (vertical, anteroposterior and mid-lateral), individually and in the form of the vector magnitude (VM)[6].

Although the use of accelerometers have grown in recent years, systematic reviews indicate the need to standardize the methods of measuring PA used in studies in Brazil. This standardization allows greater comparability of results among different studies, which is important in establishing and consolidating the associations between PA and health outcomes[7-9]. The accelerometers have a proprietary algorithm that performs the treatment of the generated data, which makes it impossible for the scientific community to develop a universal method that increases the comparability between the outputs of these devices.

There is a need to create a device that is comparable to the most widely used devices in the literature in order to reproduce studies and give continuity to them with a cheaper accelerometer in relation to those found in the market and with the possibility of presenting transparency in the data processing. The accelerometry device TrackHealth (TH) developed by researchers from the Federal University of Triângulo Mineiro, emerges with the proposal of presenting comparability and low cost allowing researchers to replicate studies that use accelerometry. However, for TH to be inserted in the scientific environment, it needs to present comparability with other devices in the outputs generated.

Thus, the present study aimed to test the psychometric indexes of validity based on the comparability of acceleration data from the TrackHealth accelerometry device with the ActiGraph® GT3X.

METHOD

Research design

This is a methodological study of applied research for validation of a research instrument with a quantitative approach. It was approved by the Research Ethics Committee (CEP) with human beings of the Federal University of Triângulo Mineiro under protocol n° 3.139.204 /2019 and the protocol was written in accordance with the standards established by the Declaration of Helsinki. The accelerometry data generated by two devices in a treadmill test were compared in order to validate a physical activity monitor comparable to the existing ones and more accessible financially to the academic community.

Sample

The sample consisted of 30 adult individuals of both sexes selected by convenience. Inclusion criteria for the study were: healthy adults, age range: 18-35 years, and agreement to take part in the study. Exclusion criteria were: any pathology/mechanical limitation that prevented the use of the treadmill and regular consumption of drugs such as antihistamines and drugs to combat vertigo that could influence the applicability of the test.

Socio-demographic, anthropometric and behavioral characteristics

To characterize the sample, variables such as gender, age, body mass, and height were collected. Body mass and height were measured by using a digital scale with an attached infrared stadiometer (WISO, W-721 with 100 g precision). To calculate the BMI (Kg/m^2), the formula [body mass (kg)/height (m2)] was adopted.

Accelerometry

The physical activity monitors used for the research protocol were the ActiGraph® wGT3X-BT triaxial accelerometer (ActiGraphCorp, LLC, Pensacola, FL,19 g; 4.6cm x 3.3cm x 1. 5cm), a small device that measures accelerations between ± 6G at a sampling rate of up to 100Hz and the TrackHealth accelerometer (Universidade Federal do Triangulo Mineiro, 50g; 7,8cm x 3,8cm x 2,0cm), a device that measures accelerations between ± 8G at a sampling rate of 80Hz, with a storage capacity of 8gb, with data generated stored by the MICROSD 5V module, powered by a 9V 150mah alkaline battery and a MPU-6050 module where the accelerometer is inserted. The device's operating code and the operating routine was made by programming the microprocessor Pro mini 324p used in the accelerometer construction.

The ActiGraph® wGT3X-BT accelerometer was initialized to collect data in raw mode (multiples of G-force) at 80 Hz sampling rate through the ActiLife® software. The TrackHealth uses the "plug play" system, the device was connected to the battery and started capturing data instantly. In the operational code, we developed a system that recorded data on the SD card on a minute-by-minute basis. For recording activity data, the beginning of the activity was timed and recorded for the subsequent cutting of activities, being paired with the start time (local time) of the ActiGraph® device.

The accelerometers were attached through an adjustable strap containing the devices around the hip. The devices were positioned on the anterior axillary line of the non-dominant side. At the end of each speed, the belt containing the accelerometers remained with the participant.

Collection protocol

The participants recruited by convenience were undergraduate or graduate students of the city of Uberaba, MG. Prior to the application of the research protocol, a pilot study was conducted for adjustments and preparation of the collection team, which was composed of professionals and collaborators from the health and electrical engineering areas. The activity protocol consisted of 4 (four) activities (walking at 4.8 and 6.4 km h^1 and running at 9.7 and 12 km h^1) performed in a laboratory (Ibramed treadmill) lasting for five minutes each, as proposed by Freedson[10] and Sasaki[6] for validation of accelerometry devices. After the participants completed each speed, a fiveminute resting period was allowed, through a bench positioned on the treadmill, removed at the beginning of the activity, with the devices remaining on the participants until the end of the test. The data of the participants who exceeded one minute at each speed were computed for analysis. Before the beginning of the tests, the participants were instructed not to exercise and to fast for at least 3 (three) hours, and to not consume caffeine or alcohol in the same day.

The download of the ActiGraph accelerometry device was made by converting the data to g-force (raw data) through the ActiLife® device, selecting the time-blocks of activities performed; the TrackHealth device does not have a software developed yet, thus an export procedure of the data in csv. file, timed from the activity through the device's memory card, was performed. Data alignment was achieved by transforming the data from both devices into seconds of execution for the four speeds of the treadmill test.

Statistical procedure

Data were tabulated in ActiLife 6.0 version and Excel, and analyzed through Matlab R2018a software. The data were tabulated with averages of 30 seconds for each speed of the activity protocol. This procedure was conducted to facilitate data treatment due to the high sampling of values generated by each device. Descriptive statistics were used to characterize the sample (relative and absolute frequency, average and standard deviation). To determinate the level of agreement between the accelerometers from ActiGraph® and TrackHealth, we applied linear regressions, Person (r) correlation tests and Bland-Altman scatterplot. The significance level of $P \leq 0,05$ was adopted for every analysis and reliability interval (IC95%). For interpretation of the Pearson correlation tests, the criteria from Landis and Koch (1977) were taken into account for data interpretation: a) almost perfect 0,80-1,00; b) substantial: 0,60-0,80; c) moderate: 0,400,60; d) regular: 0,20-0,40; e) discrete:0-0,20; f) poor: -1,00-0.

RESULTS

The sample was composed of 30 participants with a mean age of 26.3 (SD= ± 4.2) years, 75% being male (n=25), with a mean height of 174 cm (SD=± 0.05), mean body mass of 77.5 kg (SD= ± 15.3) and mean BMI of 25.5 (SD= ± 4.8).

It was possible to notice that the TH device presented a difference in relation to the ActiGraph® model, but data trend was also linear, which can be confirmed in Figure 1a, so as to show that the amplitude of variation of the acceleration increases with time. This linearity was not maintained by the ActiGraph® device (Figure 1b), since it concentrated all the gravity acceleration in the Y-axis, which can be explained by some offset adjustment established by this device.

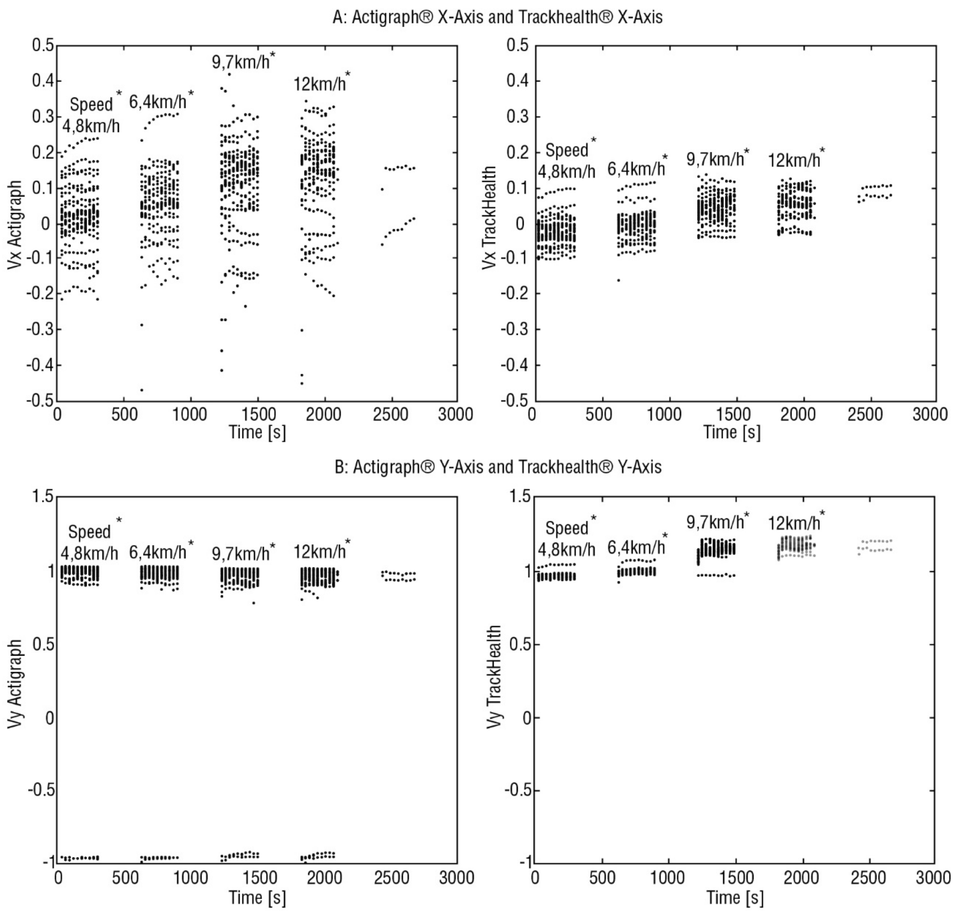

Figure 1. A - Comparison of the x-axis to Actigraph® and Trackhealth® of mean triaxial gross acceleration in four different speeds in treadmill testing. (* indicates treadmill test speeds (4.8km, 6.4km, 9.8km and 12km); B - Comparison of the y-axis to Actigraph® and Trackhealth® of mean triaxial gross acceleration in four different speeds in treadmill testing. (* indicates treadmill test speeds (4.8km, 6.4km, 9.8km and 12km). Note. Vector of the z-axis of the accelerometers in g as a function of run time in seconds.

In the Z-axis (Figure 2), there is greater comparability of the values found for acceleration between the two devices as a function of time. As for the magnitude vector (Figure 3), even with linearity, the values in the last time slices present greater discrepancy (about 0.35 g).

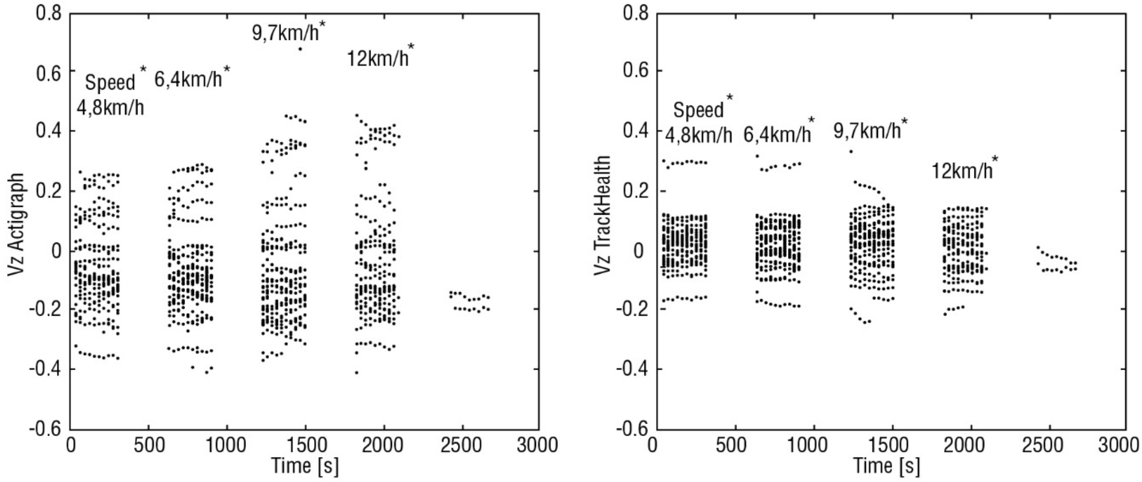

Figure 2. Comparison of the z-axis to Actigraph® and Trackhealth® of mean triaxial gross acceleration in four different speeds in treadmill testing. (* indicates treadmill test speeds (4.8km, 6.4km, 9.8km and 12km).Note. Vector of the z-axis of the accelerometers in g as a function of run time in seconds.

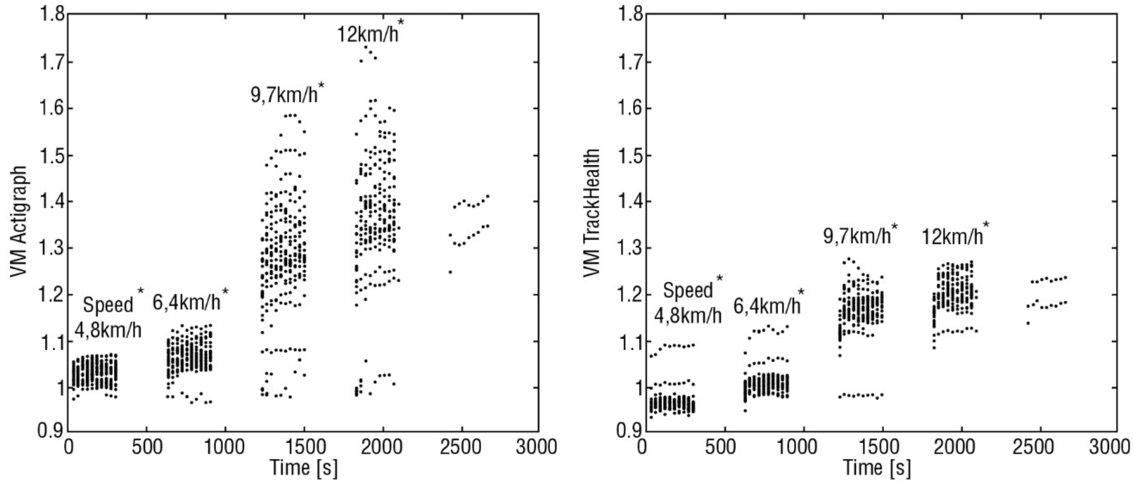

Figure 3. Comparison of Vector magnitude (VM) Actigraph® and Vector magnitude (VM) Trackhealth® of mean triaxial gross acceleration in four different speeds in treadmill testing. (* indicates treadmill test speeds (4.8km, 6.4km, 9.8km and 12km). Note. Vector magnitude in g as a function of run time in seconds.

Figure 4 shows that even though there is linear progression, since there is a difference in sensitivity between the two devices, the proportionality of the data cannot be maintained. However, even with the difference, there was a strong correlation (r=87).

The Bland Altman plot (Figure 5) shows the average of the values obtained for vector magnitude data of the two devices for the four speeds (4.8 km, 6.4 km, 9.8 km and 12 km) and showed a high agreement between the first speeds with values of coefficient of variation (CV) of 2.8% and 2.7%. However, in the last speeds, there was a weak agreement between the two devices, with CVs of 8.0% and 9.6% respectively, admitting a confidence interval of 95%.

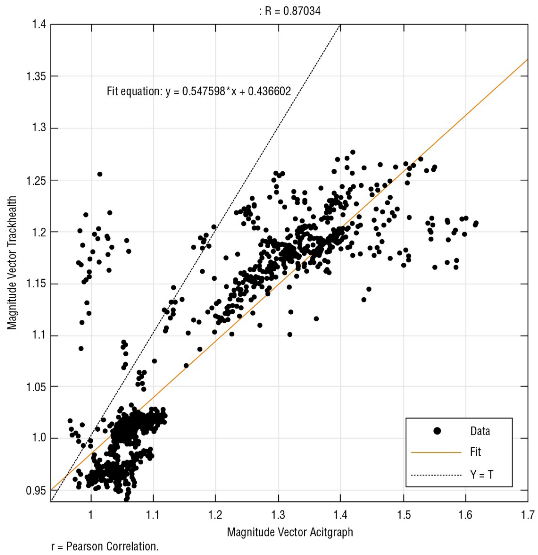

Figure 4. Linear regression of the magnitude vector of TrackHealth® and ActiGraph® devices.

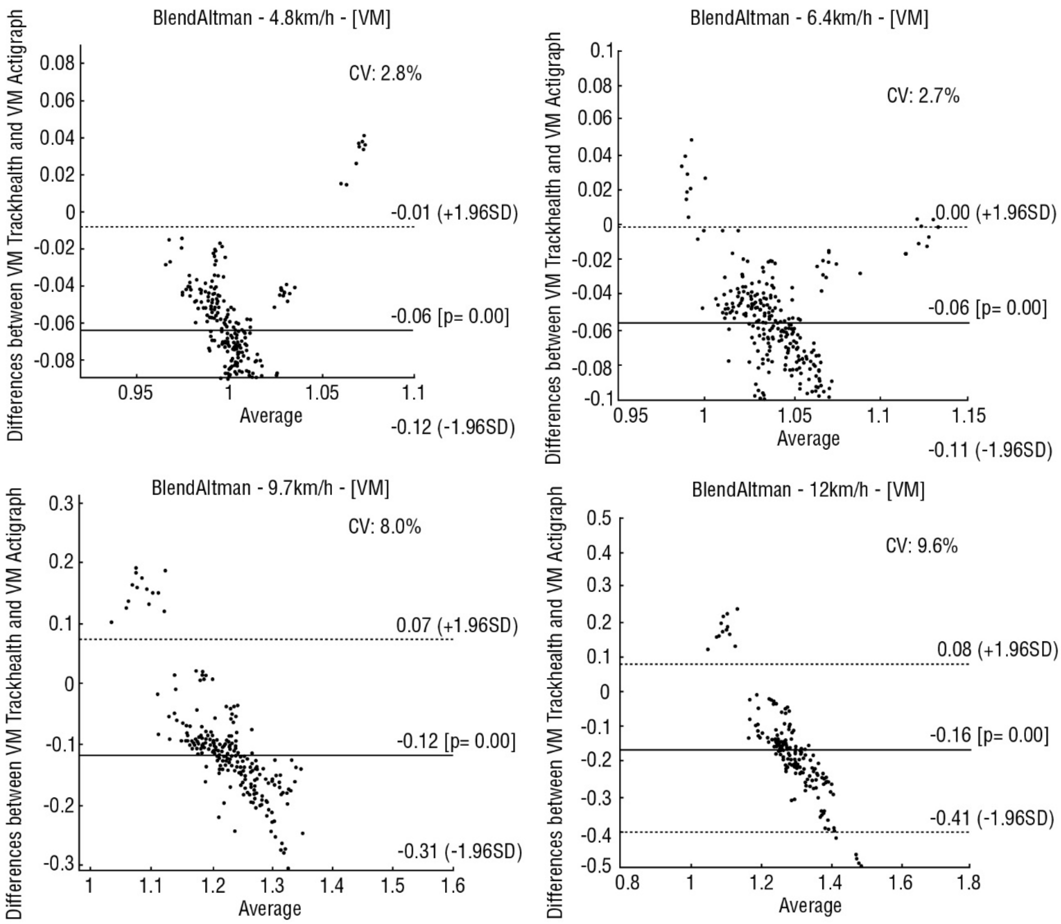

Figure 5. Bland-Altman plots evaluating the agreement between the Magnitude Vectors of the Accelerometers. Note. Bland - Altman plots evaluating the agreement between raw activity data at 4.8km, 6.4km, 9.8km, 12km speeds from the monitors, ActiGraph® and TrackHealth. Dotted lines represent 95% limits of agreement (± 1.96 SD).

DISCUSSION

This study compared the raw acceleration data between the ActiGraph® wGT3+ and TrackHealth physical activity monitors during walking and running on a treadmill. It was noted that the TH device showed better behavior in relation to acceleration at the first speeds in the x, z axes and the vector magnitude, demonstrating that the HT device has greater sensitivity in terms of data captured at speeds representing light (4.8km) and moderate (6.4km) activities. On the y-axis, it was noted that there was a discrepancy between the devices at all speeds.

The discrepancy between the monitors at raw accelerations may be attributed to inconsistencies in the data processing of the ActiGraph® device, since the data behavior on the y-axis (Figure 1b) may be related to proprietary filtering processes. There is a need for investigations to determine whether correction factors can be applied between devices in generating equivalence of accelerometer-derived data, as corrections may entail exponential scaling of output from one monitor to another[11]. However, such a factor would be beneficial, as it would require more transparency among accelerometer manufacturers leading to a reduction in differences between monitors.

Other factors may generate differences between displays in raw acceleration, such as signal processing and analog digitization, since the ActiGraph® wGT3X+ accelerometer manufacturer offers pre-programmed and user-programmable low-pass filtering[11]. These differences between monitors in low-pass filtering of analog signals can result in differences in acceleration. Factors such as differences in zero-g offset, reference voltage, and analog-to-digital bit rate conversion can also directly interfere with the comparability of acceleration devices[12].

For the raw acceleration data, although the magnitude is larger for wGT3X+ than for TrackHealth, there is strong correlation of the two monitors (Figure 4). Therefore, it may be possible to apply classification algorithms based on raw acceleration features developed on one device to the other by simply applying a conversion to the measured acceleration values. The strong correlation between the measurements (r= 0.87) by the magnitude vector of the two brands suggests that applying an appropriate conversion factor should make the values interchangeable between the two brands.

When analyzing the Bland-Altman scatter plot in relation to the magnitudes vectors of the two devices at the four speeds, there is a difference in agreement between the accelerations generated in the treadmill test (Figure 5) in relation to the final speeds. This result shows greater concentration at the lower limit of the graph, suggesting a tendency to underestimate the accelerations as the speed increases.

However, there is no way to say which device is underestimating the acceleration values, since the filtering process of accelerometry devices may use some kind of proprietary filtering even when using raw data[13] making direct comparison between devices impossible. John[11] points out that there is a need for consensus among physical activity measurement experts on the movements and related acceleration signal characteristics that are sufficient to represent a step, and such consensus should be used to expedite the development of an open source, non-proprietary step detection methodology.

Nonetheless, it was possible to notice that the coefficient of variation (CV) at initial velocities was positive, presenting values between 2.8 and 2.7%, demonstrating that the device presents greater agreement in relation to the ActiGraph device at lower intensity activities, generating discrepancy between higher velocities. A study by Paul[14] also found CV values between 2-3% demonstrating that it is possible to produce accurate PA group median values.

The TH device still needs adjustments of parameters in the code to improve the development of the data processing algorithm. This factor contributes to the need of creating a software program that reads the data generated during the collection, since the high sampling data requires a program to treat the noises that are incorporated into the signal and to plot these results in a way that facilitates the interpretation of researchers. Another point is the fact that the device is under construction, since the calibration with metabolic data for the prediction of physical activity levels must still be tested to validate this device.

According to our results, it was not possible to reach the level of difference less than 5% in the final speeds in relation to the other device, which shows the need for further research using TrackHealth in order to promote a device with more reliability and comparability.

CONCLUSION

Differences were found between the ActiGraph® wGT3X+ and TrackHealth with regard to raw accelerations during treadmill running speed. The findings suggest to the research community that it may be unrealistic to expect complete equivalence of outputs between monitors. Nonetheless, the device will go through several steps in the refinement process, and software will need to be created to read and process the data, and pilot projects will also need to be conducted to test the durability of the device in different situations.

As potential limitations, we can consider having only one TrackHealth device available, which was produced for the research, while there were five ActiGraph® units. This results in an open problem to compare the results between TrackHealth accelerometers from the same generation. Another limitation was the sample size for applying the walking and running protocol (30 subjects), which decreases the power of inference.

Therefore, it is suggested that calibration studies of the devices that are being commercialized could be conducted to clarify aspects of proprietary filtering of the data to ensure greater comparability between accelerometry devices in order to standardize this process.

COMPLIANCE WITH ETHICAL STANDARDS

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. This study was funded by the authors

Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee – at the Federal University of Triângulo Mineiro (UFTM) and the protocol no. 3.139.204 /2019 was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: RAO, JSVJ. Performed the experiments: RAO, JSVJ, JES, ARGO. Analyzed the data: RAO, PHAM, NLF, ARGO. Contributed reagents/materials/analysis tools: RAO, JSVJ, JES, PHAM. Wrote the paper: RAO, JSVJ, JES, NLF, ARGO.

REFERENCES

1. Knuth AG, Malta DC, Cruz DK, Castro AM, Fagundes J, Sardinha LM, et al. Description of the countrywide physical activity network coordinated by the Brazilian Ministry of Health: 2005-2008. J Phys Act Health 2010;7(Suppl 2):S253-8. http://dx.doi.org/10.1123/jpah.7.s2.s253. PMid:20702913.
2. Chen KY, Bassett DR Jr. The technology of accelerometry-based activity monitors: current and future. Med Sci Sports Exerc 2005;37(11, Suppl):S490-500. http://dx.doi.org/10.1249/01.mss.0000185571.49104.82. PMid:16294112.
3. Motl RW, Snook EM, Agiovlasitis S, Suh Y. Calibration of accelerometer output for ambulatory adults with multiple sclerosis. Arch Phys Med Rehabil 2009;90(10):1778-84. http://dx.doi.org/10.1016/j.apmr.2009.03.020. PMid:19801071.
4. Serra MC, Balraj E, DiSanzo BL, Ivey FM, Hafer-Macko CE, Treuth MS, et al. Validating accelerometry as a measure of physical activity and energy expenditure in chronic stroke. Top Stroke Rehabil 2017;24(1):18-23. http://dx.doi.org/10.1080/10749357.2016.1183866. PMid:27322733.
5. Montoye AHK, Moore RW, Bowles HR, Korycinski R, Pfeiffer KA. Reporting accelerometer methods in physical activity intervention studies: a systematic review and recommendations for authors. Br J Sports Med 2018;52(23):1507-16. http://dx.doi.org/10.1136/bjsports-2015-095947. PMid:27539504.
6. Sasaki JE, John D, Freedson PS. Validation and comparison of ActiGraph activity monitors. J Sci Med Sport 2011;14(5):411-6. http://dx.doi.org/10.1016/j.jsams.2011.04.003. PMid:21616714.
7. Bassett DR, Troiano RP, McClain JJ, Wolff DL. Accelerometer-based physical activity: total volume per day and standardized measures. Med Sci Sports Exerc 2015;47(4):833-8. http://dx.doi.org/10.1249/MSS.0000000000000468. PMid:25102292.
8. Ruiz JR, Ortega FB, Martínez-Gómez D, Labayen I, Moreno LA, De Bourdeaudhuij I, et al. Objectively measured physical activity and sedentary time in European adolescents: the HELENA study. Am J Epidemiol. 2011;174(2):173-84. http://dx.doi.org/10.1093/aje/kwr068. PMid:21467152.
9. Silva I, Sasaki J, Gonçalves P. Mensuração da atividade física e tempo sedentário por meio de acelerômetros: cenário atual, perspectivas e demandas futuras. Rev Bras Ativ Fís Saúde 2016;21(4):293-6. http://dx.doi.org/10.12820/rbafs.v.21n4p293-296.
10. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. Med Sci Sports Exerc 1998;30(5):777-81. http://dx.doi.org/10.1097/00005768-199805000-00021. PMid:9588623.
11. John D, Morton A, Arguello D, Lyden K, Bassett D. "What Is a Step?" Differences in how a step is detected among three popular activity monitors that have impacted physical activity research. Sensors 2018;18(4):1206. http://dx.doi.org/10.3390/s18041206. PMid:29662048.

12. Miller J. Accelerometer technologies, specifications and limitations. In: Internationational Conference on Ambulatory Monitoring and Physical Activity Measurement; 2013 June 17-19; Amherst. Proceedings. Bristol: IOP Publishing Ltd; 2013.

13. Matthew CE. Calibration of accelerometer output for adults. Med Sci Sports Exerc 2005;37(11, Suppl):S512-22. http://dx.doi.org/10.1249/01.mss.0000185659.11982.3d. PMid:16294114.

14. Paul DR, Kramer M, Moshfegh AJ, Baer DJ, Rumpler WV. Comparison of two different physical activity monitors. BMC Med Res Methodol 2007;7(1):26. http://dx.doi.org/10.1186/1471-2288-7-26. PMid:17592631.