Original Article

JER

https://doi.org/10.12965/jer.2346576.288

Journal of Exercise Rehabilitation 2023;19(6):370-374

The influence of accelerometer epoch length on physical activity output in adolescent athletes

Jae-Hyun Lee, Soonhyun Kwon, Soyoon Lee, Se-Yeon Jang, Wooyeon Jo, Jaeho Jin, Yaxiong Zheng, Sang Ki Lee*

Department of Sport Science, Chungnam National University, Daejeon, Korea

Epoch in accelerometer measurements is an important option that affects the results of physical activity (PA) analysis. Many studies have been conducted to investigate the effect of epoch on PA output in adolescents, but few have been performed on highly active youth athletes. We aimed to examine the differences in energy expenditure and time spent in different activity intensities by applying various epoch lengths in adolescent athletes. The participants of this study comprised 31 male athletes aged 12 to 13 in basketball, soccer, and taekwondo teams. Athletes wore a tri-axial accelerometer attached to the right hip for 6 to 7 consecutive days, including sleeping time. Subsequently, the recorded data from the accelerometer were downloaded using the ActiLife software and analyzed by varying the epoch to 1, 10, 30, and 60 sec. Daily average metabolic equivalents (METs) increased as the epoch increased ($F=2.918$, $P=0.037$), showing a significant difference between 1 and 60-sec epochs. As epoch length increased, sedentary (0–1.5 METs) ($F=94.001$, $P=0.000$) and high intensity (6 METs and higher) activity time ($F=3.536$, $P=0.017$) decreased, while low (1.5–3 METs) ($F=173.949$, $P=0.000$), moderate (3–6 METs) ($F=70.792$, $P=0.000$), and moderate-to-vigorous activity (3 METs and higher intensity) ($F=34.683$, $P=0.000$) times increased. Comparing PA among adolescent athletes by varying epoch settings of accelerometers revealed differences in PA levels and time spent in different activity intensities. Future studies should consider the characteristic changes in the PA outputs according to the epoch length in very active adolescent athletes.

Keywords: Physical activity, Accelerometer, Epoch, Adolescence, Athlete

INTRODUCTION

Excessive energy expenditure during rapid growth period due to intense training may lead to an inadequate energy reserve essential for sustained growth, potentially impacting the health and athletic performance of youth athletes (Meyer et al., 2007). Therefore, the objective quantification of physical activity (PA) through precise measurements is important for effective health management among adolescent athletes. The accelerometer has been used as a useful tool for the objective measurement of PA across various age demographics (Cain et al., 2013; Lynch et al., 2019; Silveira et al., 2022). Nevertheless, it has been known that outputs derived from accelerometer data are subject to alteration based on epoch length, criteria for data inclusion, cutoff point for PA intensity and wearing determination algorithms during data processing (Cain et al., 2013; Logan et al., 2016; Migueles et al., 2017). Consequently, selecting appropriate processing parameters aligned with the subject's activity patterns becomes imperative.

Children and adolescent activity patterns are characterized by intermittent high intensity in daily life comparing with adults and older adults. To accurately capture these patterns, multiple studies have investigated the optimal epoch length for accelerometers. Epoch length refers to the duration over which activity counts are aggregated and recorded, significantly impacting estimations of moderate-to-vigorous PA in young individuals. Notably, numerous studies advocate for shorter epochs, such as one sec because longer epoch lengths tend to underestimate vigorous activity among children and adolescents.

For groups engaged in extremely high-intensity activities, like adolescent athletes, a shorter epoch setting may be indispensable. However, recent research by Fabre et al. (2023) showed that, when analyzing intermittent running, epoch lengths of 30 and 60 sec

*Corresponding author: Sang Ki Lee https://orcid.org/0000-0001-8507-564X
Department of Sport Science, Chungnam National University, 99 Daehak-ro, Yuseong-gu, Daejeon 34134, Korea
Email: nicelsk@cnu.ac.kr
Received: October 23, 2023 / Accepted: November 30, 2023

pISSN 2288-176X
eISSN 2288-1778

yielded results more closely aligned with energy expenditure and moderate-to-vigorous activity time measured through indirect calorimetry. Therefore, to comprehensively assess the difference of PA pattern, applying both short and long epochs seems necessary. This study was part of the 'Research Project on the Effects of Youth Athletes' Exercise, Nutrition, Sleep, and Stress on Growth and Development.' The purpose of this study was to compare accelerometer outputs based on epoch length. By examining variations in time spent at different PA intensities and overall energy expenditure as dictated by accelerometer epoch settings, we aim to establish foundational data for investigating the impact of adolescent athletes' activity on growth in future research.

MATERIALS AND METHODS

Participants

The study participants were 12 to 13 years old adolescent male athletes who belonged to basketball (5 athletes), taekwondo (7 athletes), soccer (19 athletes) team. They were in the first grade of middle school and registered in the Korea Association of Athletics Federations. The athletes who could not maintain ordinary PA or training due to injury or disease and participating in the special events such as sport match or group traveling were excluded. The physical characteristics of the subjects were presented in Table 1. The Ethics Committee of Chungnam National University (2023-01-SB-010-01) approved this study. Prior to the investigation, the athletes and their parents were given a detailed explanation of the background, objectives, and procedures of the study and consented to participate in the study with documents.

Accelerometer processing

All participants were asked to wear a GT3X accelerometer for 7 consecutive days including sleeping hours except for periods when the device may get wet such as showering or swimming. Each accelerometer was set to collect tri-axial acceleration signals at 30 Hz. Accelerometers were attached to an elasticated belt and positioned on the right hip securely. After 7 days, accelerometers were collected and downloaded for data processing and reduction using Actilife.

Table 1. Characteristics of study participants (n = 31)

Variable	Mean ± SD
Age (yr)	13.30 ± 0.26
Height (cm)	164.41 ± 9.58
Weight (kg)	55.52 ± 13.24
Body mass index (kg/m^2)	20.31 ± 3.38

SD, standard deviation.

A valid day was determined as ≥ 10 hr of monitoring per day (Migueles et al., 2017). Participants with less than 4 days of recording were excluded from the analysis (Toftager et al., 2013). Epoch length was set to 1 sec and reintegrated into longer periods of 10, 30, 60 sec. To determine the time spent in sedentary (< 1.5 metabolic equivalents, METs), light (≥ 1.5 METs and < 3 METs), moderate (≥ 3 METs and < 6 METs), vigorous (≥ 6 METs and < 9 METs), very vigorous (> 9 METs), and moderate-to-vigorous PA (≥ 3 METs), the cutoff points derived by Freedson et al. (2005) were used.

Data analysis

The descriptive data were expressed as the mean values with standard deviations for continuous variables. One way analysis of variance was used to compare the energy expenditure and time spent on PA of each intensities (sedentary, light, moderate, vigorous, very vigorous) among the epoch options (1, 10, 30, 60 sec). Bonferroni test was performed for the *post hoc* analysis of the variables showing statistical significance. All statistical analyses were conducted using IBM SPSS Statistics ver. 26.0 (IBM Co., Armonk, NY, USA) and $P < 0.05$ was considered significant.

RESULTS

Energy expenditure and PA level (METs) showed an increase as the epoch length increased, but only METs was statistically significant ($F = 2.918$, $P = 0.037$) (Table 2). Except for the vigorous (6–9 METs) activity time, a statistically significant differences were found depending on the epoch length in the time spent on all other activity intensities. As the epoch length was set longer, light ($F = 173.95$, $P = 0.00$), moderate ($F = 70.79$, $P = 0.000$), and moderate-vigorous PA ($F = 34.68$, $P = 0.000$) increased, and sedentary ($F = 94.00$, $P = 0.000$), very vigorous ($F = 13.78$, $P = 0.000$), and vigorous to very vigorous activity ($F = 3.536$, $P = 0.017$) decreased. As a result of the *post hoc* test, sedentary and light activities were different for each epoch, and moderate and moderate-to-vigorous activities were different for each epoch, but there was no significant difference between 30 and 60 sec. Very vigorous activity showed a difference between epoch 1 sec and other epochs, and vigorous to very vigorous activity showed a significant difference between epoch 1 sec and 60 sec (Table 3).

Table 2. Comparison of the physical activity according to the various epoch length (n=31)

Physical activity	Epoch length				*F*-value	*P*-value
	1 sec	10 sec	30 sec	60 sec		
Energy expenditure on PA (kcal/day)	761.25±349.07	773.07±377.94	780.19±389.79	782.84±395.05	0.020	0.996
METs	1.64±0.13[a]	1.69 ±0.13[ab]	1.71±0.13[ab]	1.73±0.13[b]	2.918	0.037

Values are presented as mean±standard deviation.
PA, physical activity; METs, metabolic equivalents.
Values with different alphabets in the same row are significantly different at *P*=0.05 by a Bonferroni test.

Table 3. Comparison of time spent on physical activity of various intensities according to the epoch lengths (n=31)

Time spent	Epoch length				*F*-value	*P*-value
	1 sec	10 sec	30 sec	60 sec		
Sedentary (min)	1,192.51±36.33[a]	1,091.64±46.08[b]	1,033.88±52.51[c]	999.02±56.94[d]	94.001	0.000
Light (min)	37.10±5.76[a]	89.74±14.73[b]	118.95±21.77[c]	138.09±25.61[d]	173.949	0.000
Moderate (min)	147.62±23.69[a]	200.79±29.19[b]	234.84±33.14[c]	254.36±36.31[c]	70.792	0.000
Vigorous (min)	38.29±8.30	43.12±10.80	41.94±13.06	40.30±14.87	0.945	0.421
Very vigorous (min)	24.04±11.51[a]	14.38±11.28[b]	10.19±10.14[b]	8.23±9.11[b]	13.784	0.000
Vigorous-Very vig. (min)	62.33±4.78[a]	57.51±17.12[ab]	52.13±18.71[ab]	48.53±20.62[b]	3.536	0.017
Mod-Vigorous (min)	209.96±32.78[a]	258.30±37.53[b]	286.98±40.12[c]	302.89±43.09[c]	34.634	0.000

Values are presented as mean±standard deviation.
Vigorous-Very Vig., vigorous-to-very vigorous activity time; Mod-Vigorous, moderate-to-vigorous activity time.
Values with different alphabets in the same row are significantly different at *P*=0.05 by a Bonferroni test.

DISCUSSION

Epoch length significantly impacts the outcomes in PA analysis (Aibar and Chanal, 2015; Cain et al., 2013; Fabre et al., 2020; Sanders et al., 2014), with recommendations of short epochs, typically ranging from 1 to 15 sec, for children and adolescents usually engaged in intermittent high-intensity activities (Fabre et al., 2020; Migueles et al., 2017).

In this study involving male athletes aged 12–13 exhibiting frequent bursts of high-intensity intermittent activities, there was also a difference in time for each intensity according to epoch length, and the shorter the epoch length, the higher the vigorous to very vigorous activity time (6 and higher MET). At the same time, the sedentary time also increased, and the moderate and moderate-vigorous activity time decreased as the epoch decreased. Reflecting these results, the shorter the epoch, the PA level decreased showing statistical significance in the average daily activity level presented by MET. The results of this study are partially different from previous studies on children and adolescents' PA. As epoch length increases, the decline in vigorous to very vigorous activity aligns with previous findings, yet the increase in moderate-vigorous activity diverges from established research (Aibar et al., 2014; Logan et al., 2016; Migueles et al., 2017). It appears that the increase in moderate activity time outweighs the decrease in vigorous to very vigorous activity time as the epoch length increases. The comparison between 1-sec and 60-sec epochs showed a disparity of 106.7 min in moderate activity and 13.8 min in vigorous to very vigorous activity time. The same results as this study were seen in several other studies, which were measured in physical education classes (Sanders et al., 2014) and intermittent treadmill running (Fabre et al., 2020) situations. In this study, daily life was measured, but the level of activity was very high because they were athletes, so it seems to be similar to the case of high level of activity such as physical education classes and intermittent running.

For adolescents, shorter epoch lengths have been recommended to counter the dilution effect on high-intensity activities when applying long epoch lengths. However, it should be considered that the short epoch setting might be accompanied by an increase in sedentary time, decrease in light, moderate, moderate-vigorous activity time, and general MET when comparing with PA outputs under long epoch setting. In addition, it is noteworthy that the energy expenditure calculated by the accelerometer may be lower than the actual energy expenditure because the level of energy metabolism increases physiologically even if there is no physical movement during the intermittent or interval exercise, resulting

https://doi.org/10.12965/jer.2346576.288

in a closer output to the criteria value when a longer epoch is set. Fabre et al. (2023) reported this by comparing the energy expenditure calculated using the accelerometer and the indirect calorimetry, and they reported that the energy expenditure calculated by the accelerometer during intermittent running was consistently lower than the energy expenditure calculated by the indirect calorimetry, and that the result was closer to the criterion measure than the shorter epoch setting when the epoch was set at 30 and 60 sec.

In many studies of adolescents, PA is usually investigated in relation to health, and the most meaningful PA indicators are not only vigorous activities, but also energy expenditure, moderate-to-vigorous activity, and sedentary hours (Joensuu et al., 2018; Papadopoulou et al., 2021; Skinner et al., 2023; Wang et al., 2019). This study also analyzes PA as part of a project to investigate the impact of youth athletes' lifestyle on their growth and development, so in future research, it might be better to consider both of a short epoch that can better capture physical movements and a long epoch that can better reflect physiological energy expenditure levels.

In conclusion, when measuring PA of adolescent athletes using accelerometers, the shorter the epoch length, compared to the long epoch setting, the higher the high-intensity activity and sedentary time, and the lower the low, moderate, moderate-to-vigorous activity time and average activity level. We will consider this when we perform the study on the impact of youth athletes' activity level on their growth and development.

CONCLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENTS

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2022S1A5B5A16052443).

REFERENCES

Aibar A, Bois JE, Zaragoza J, Generelo E, Julián JA, Paillard T. Do epoch lengths affect adolescents' compliance with physical activity guidelines? J Sports Med Phys Fit 2014;54:255-263.

Aibar A, Chanal J. Physical education: the effect of epoch lengths on children's physical activity in a structured context. PLoS One 2015;10:e0121238.

Cain KL, Sallis JF, Conway TL, Van Dyck D, Calhoon L. Using accelerometers in youth physical activity studies: a review of methods. J Phys Act Health 2013;10:437-450.

Fabre N, Lhuisset L, Bernal C, Bois J. Effect of epoch length on intensity classification and on accuracy of measurement under controlled conditions on treadmill: towards a better understanding of accelerometer measurement. PLoS One 2020;15:e0227740.

Fabre N, Lhuisset L, Bois J. Accelerometer-based physical activity assessment during intermittent conditions: effect of epoch length on energy expenditure estimate. Res Q Exerc Sport 2023;94:202-209.

Freedson P, Pober D, Janz KF. Calibration of accelerometer output for children. Med Sci Sports Exerc 2005;37(11 Suppl):S523-S530.

Joensuu L, Syväoja H, Kallio J, Kulmala J, Kujala UM, Tammelin TH. Objectively measured physical activity, body composition and physical fitness: cross-sectional associations in 9- to 15-year-old children. Eur J Sport Sci 2018;18:882-892.

Logan GR, Duncan S, Harris NK, Hinckson EA, Schofield G. Adolescent physical activity levels: discrepancies with accelerometer data analysis. J Sports Sci 2016;34:2047-2053.

Lynch BA, Kaufman TK, Rajjo TI, Mohammed K, Kumar S, Murad MH, Gentile NE, Koepp GA, McCrady-Spitzer SK, Levine JA. Accuracy of accelerometers for measuring physical activity and levels of sedentary behavior in children: a systematic review. J Prim Care Community Heal 2019;10:2150132719874252.

Meyer F, O'Connor H, Shirreffs S. Nutrition for the young athlete. J Sports Sci 2007;25 Suppl 1:S73-S82.

Migueles JH, Cadenas-Sanchez C, Ekelund U, Delisle Nyström C, Mora-Gonzalez J, Löf M, Labayen I, Ruiz JR, Ortega FB. Accelerometer data collection and processing criteria to assess physical activity and other outcomes: a systematic review and practical considerations. Sport Med 2017;47:1821-1845.

Papadopoulou SK, Feidantsis KG, Hassapidou MN, Methenitis S. The specific impact of nutrition and physical activity on adolescents' body composition and energy balance. Res Q Exerc Sport 2021;92:736-746.

Sanders T, Cliff DP, Lonsdale C. Measuring adolescent boys' physical activity: bout length and the influence of accelerometer epoch length. PLoS One 2014;9:e92040.

Silveira EA, Mendonça CR, Delpino FM, Souza GVE, Rosa LP, Oliveira C, Noll M. Sedentary behavior, physical inactivity, abdominal obesity and obesity in adults and older adults: a systematic review and meta-analysis. Clin Nutr ESPEN 2022;50:63-73.

Skinner AM, Rowlands AV, Vlachopoulos D, Barker AR, Janz KF, Moore SA. The influence of accelerometer epoch length on associations of physical activity intensity and volume with bone outcomes. J Sport

Sci Med 2023;22:117-132.
Toftager M, Kristensen PL, Oliver M, Duncan S, Christiansen LB, Boyle E, Brønd JC, Troelsen J. Accelerometer data reduction in adolescents: effects on sample retention and bias. Int J Behav Nutr Phys Act 2013; 10:140.
Wang WY, Hsieh YL, Hsueh MC, Liu Y, Liao Y. Accelerometer-measured physical activity and sedentary behavior patterns in Taiwanese adolescents. Int J Environ Res Public Health 2019;16:4392.

https://doi.org/10.12965/jer.2346576.288