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A MODEL OF PEDOMETER DETERMINED PHYSICAL ACTIVITY IN PRIMARY SCHOOL CHILDREN

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Abstract

Objective. Steps/day count is a popular and effective method of testing of physical activity of children. The purpose of this research is to create a model of interaction between steps/day counts regarding genders, seasons of a year, and days of week.

Material and methods. Totally 74 of 4-th grade pupils (38 boys and 36 girls) from three primary schools in the industrial city were involved into the pedometer investigation. All the students were good healthy, and they participated in the schools' lessons of physical education according to the common program. Pedometer determined physical activity was measured during a day using fitness tracker band. The measurements were done during one academic year using three full weeks (a week in autumn, winter, and spring). ANOVA was used to determine differences between samples grouped according days of weeks.

Results. A strong significant difference between counts of steps during days of week for boys ($p = 0.006$) and smaller for girls ($p = 0.052$) were discovered with corresponding parts in the total variation (62.5 and 46.0 %). The same significant differences were discovered between mean counts in seasons ($p = 0.053, 0.037$) with corresponding parts in the total variation (14.5, 22.8 %). Rather significant variations of interaction between days of week and mean season results took place for boys (23.0 %) as well for girls (31.1 %).

Conclusions. During evaluation of physical activity in children based on steps/day counts, interaction between gender, season, and day of week should be taken into consideration.

Key words: physical education, pupils, fourth grade, testing, modelling.

Introduction

During last decades, alarming trends in childhood obesity even among the primary school students have re-focused attention on the importance of physical activity in this age grade (Sahoo et al., 2015). With this increased attention comes the need to identify the amount and type of physical activity appropriate for optimal development of school students (Tudor-Locke et al., 2004a). Timmons et al. (2007) provided the scientific evidence to support a link between physical activity and biological and psychosocial development during childhood.

Industry standards establishing quality control of instrumentation is limited to Japan where public health pedometer applications were produced, and the 10,000 steps/day was recognised as a cut point (Ishii et al., 2015). Adult public health guidelines promote at least 30 min of moderate-intensity daily physical activity, and this translates to 3000-4000 steps if they are: 1) at least moderate intensity (at least 100 steps/min); 2) accumulated in at least 10-min bouts; and 3) taken over and above some minimal level of physical activity (i.e., number of daily steps) below which individuals might be classified as sedentary. A zone-based hierarchy is useful for both measurement and motivation purposes in adults: less than 5000 steps/day (sedentary); 5000-7499 steps/day (low active); 7500-10,000 steps/day (somewhat active); 10,000-12,499 steps/day (active); 12,500 steps/day (highly active). Criterion-referenced approaches based on selected health outcomes present the potential for advancing evidence-based steps/day standards in both adults and children from a measurement perspective (Tudor-Locke et al., 2004b).

Gomersall et al. (2016) basing on the data in the international literature indicated that we can expect among children (typically 6-11 years), to average 12,000 to 16,000 steps/day (boys) and girls to average 10,000 to 13,000 steps/day. Limited evidence suggests that a total daily physical activity volume of 10,000-14,000 steps/day is associated with 60-100 minutes of moderate to vigorous physical activity in preschool children

(approximately 4-6 years of age). Across studies, 60 minutes of moderate to vigorous physical activity in primary school children appears to be achieved, on average, within a total volume of 13,000 to 15,000 steps/day in boys and 11,000 to 12,000 steps/day in girls (Tudor-Locke et al., 2011).

Remmers et al. (2017) undertook the first study to use a longitudinal design to investigate the influence of weather elements on children's intra-individual physical activity patterns. They distributed repeated measurements across four school terms within one year ensured variation in weather elements and are representative of yearly physical activity patterns among Australian children. Their present study's approach of physical activity patterns within individuals is different from earlier studies. These studies typically analyzed between-individual differences, aggregating physical activity for days. Within-individual analyses, such as in our study, are better able to characterize day-to-day variation in children, helping us to understand physical activity patterns in children (Mears et al., 2019). As weather influences cannot be controlled, knowledge of its influence on individual physical activity patterns may inform the design, analysis, and interpretation of future studies, especially when investigating physical activity across diverse meteorological settings and with long follow-up periods.

Mooses et al. (2018) investigated the validity of Fitbit Zipstep count, moderate to vigorous physical activity and sedentary minutes, in different school segments in 3rd grade students. There was a strong correlation in the number of steps in all in-school segments between the two devices ($r = 0.85–0.96$, $p < 0.001$). The Fitbit Zip overestimated the number of steps in all segments, with the greatest overestimation being present in physical education lessons (345 steps). As for physical activity intensities, the agreement between the two devices in physical education and recess was moderated for moderate to vigorous physical activity minutes ($r = 0.56$ and 0.72, $p < 0.001$) and strong for sedentary time ($r = 0.85$ and 0.87, $p < 0.001$). During class time, the correlation was weak for moderate to vigorous physical activity minutes ($r = 0.24$, $p < 0.001$) and moderate for sedentary time ($r = 0.57$, $p < 0.001$). For total in-school time, the correlation between the two devices was strong for steps ($r = 0.98$, $p < 0.001$), moderate to vigorous physical activity ($r = 0.80$, $p < 0.001$) and sedentary time ($r = 0.94$, $p < 0.001$).

Duncan et al. (2008) evaluated the effects of meteorological variables on the number of pedometer steps accumulated by children. They reported that a 10°C rise in mean ambient temperature was associated with a small increase in weekday steps and a moderate increase in weekend-day steps for boys, whereas for girls the effects were small and unclear, respectively. There were substantial decreases in weekday and weekend-day steps during moderate rainfall (1.1–4.9 mm) for both genders. Most effects of day length, wind speed, and hours of bright sunshine on step counts were trivial or unclear. Ambient temperature and rainfall have substantial effects on children's daily step counts and should therefore be considered when comparing physical activity across different locations or periods. Strategies to increase activity on cold or rainy days may also be appropriate (Trost et al., 2002).

Majorities of children by Belton et al. (2010) were classed as of normal weight, and met the age and gender specific pedometer recommendations for health. Children took significantly more steps at weekends than on weekdays, and after school than during school. A child being classed as normal or overweight/obese based on Body Mass Index did not predict the likelihood of them meeting the pedometer recommendations.

Computer aid monitoring of steps/day counts during last decades became to a rather popular and effective methods of pedometer determined physical activity especially in children. Dependences of steps/day counts from gender, seasons of a year, days of a week, and day time have been revealed, and correlations between these parameters have been investigated by Bassett et al. (2017).

Research problem. There are significant interactions between steps/day counts regarding genders, seasons of a year, and days of week while testing pedometer determined physical activity.

Purpose. The aim of this research was to create a model of pedometer determined physical activity taking into account the interaction between steps/day counts regarding genders, seasons of a year, and days of week.

Materials and methods

Particip ants

Totally 74 of 4-th grade students from different primary schools in a west Ukrainian industrial city were involved into the pedometer investigation. They were 38 males with body mass 28.1±1.7 kg (M±SD) and body length 134.2±2.8 cm; and 36 girls (body mass: 29.1±1.9 kg, body length: 134.7±2.7 cm). All the students were good healthy, and they participated in the schools' lessons of physical education according the common program (Ukraine, 2019). This study was approved in advance by Ethical Committee of Lviv State University of Physical Culture. Parents of each the young participant voluntarily provided written informed consent before participating. The procedures followed were in accordance with the ethical standards of the Ethical Committee on human experimentation.

Procedure

Pedometer determined physical activity was measured during a day using Fitness tracker Fitbit Charge (2015). The measurements were done during one academic year from autumn to spring. In general, the Fitbit can be considered a relatively accurate device for measuring the number of steps, moderate to vigorous physical activity and sedentary time in students in a school-setting. However, in segments where sedentary time dominates (e.g. academic classes), a research-grade accelerometer was preferred (Foley et al., 2011)

Every participant during one full week (from Monday to Sunday) in autumn (October), winter (February), and spring (May) wore a pedometer during a day. Pedometer-determined physical activity was evaluated using cut points introduced for students based on a BMI-referenced criterion study of U.S., Australian, and Swedish children 6–12 years of age (Table 1).

Statistical analysis

One-way ANOVA for repeated measures was used to determine differences between samples grouped according days of weeks. Two-ways ANOVA was used to determine differences between samples grouped according gender and

Table 1. Pedometer-determined physical activity for children (President's Council, 2016).

Physical activity level	Definition	Cut points (103 steps / day)	
		Boys	Girls
1	Sedentary	< 10,000	< 7,000
2	Low active	10,000 – 12,499	7,000 – 9,499
3	Somewhat active	12,500 – 14,499	9,500 – 11,999
4	Active	15,000 – 17,499	12,000 – 14,499
5	Highly active	> 17,500	> 14,500

season relatively weeks. Student t-test was applied in evaluation of differences between means of seasons and days of week. Variation of steps per day count was estimated with the coefficient of variation:

$$V = (SD/M)100\%, \quad (1)$$

where SD: standard deviation, M: arithmetic mean. If V < 10%, variation is small, 10–20% – moderate, and V > 20% – great (Zatsiorsky, 1982).

Calculations were done using MS Excel computer pocket analysis (Service > Analysis > Two ways ANOVA without repetition, Service > Analysis > Pared t-test for means, Service > Analysis > Two samples t-test with different variances).

Results

Mean (M), standard deviation (SD), minimal (Min) and maximal (Max) steps during a day, and coefficient of variation (V) are collected in Table 2 regarding gender (males and females) and seasons (autumn, winter, and spring).

Physical activity in the studied group varied significantly between participants (Figure 1): steps/day count in the group was rather different every day (V > 20 %).

Relatively the maximum count of steps/day, participants showed pedometer-determined physical activity evaluated using the scale (Tudor-Locke et al., 2008) as sedentary (9.4 % boys and 8.3 % girls), low active (25.7, 17.5 %), somewhat active (30.1, 37.8 %), active (18.6, 18.1 %), and highly active (16.2, 18.3 %). Using mean counts of steps/day physical activity of studied groups was evaluated as sedentary in males and low active in females with 9224 and 7370 steps/day correspondingly.

According to the two-ways ANOVA, significant difference was noticed between boys and girls in steps/day count,

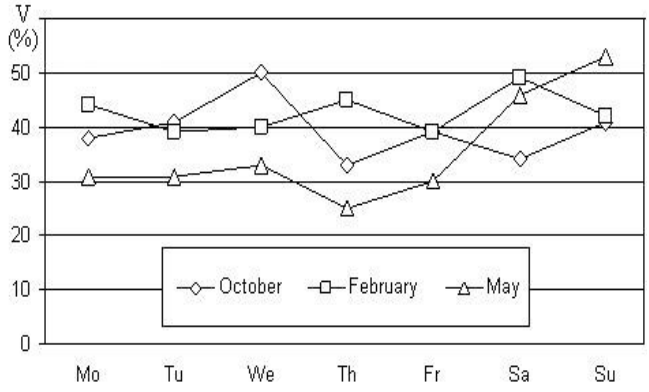

Fig. 1. Variation of steps/day count in the group studied

Table 2. Steps counts per day (thousands) parameters: M±SD (Min–Max), V(%)*

Day	Autumn	Winter	Spring
		Males	
Monday	8,671±3,517 (4,435–13,538), 40.6%	8,621±3,407 (3,632–12,655), 39.5%	10,573±3,579 (2,499–14,097), 33.8%
Tuesday	9,320±3,830 (3,485–13,790) 41.1%	9,213±3,987 (6,261–17,652), 43.3%	11,670±3,513 (6,753–17,618), 30.1%
Wednesday	9,604±4,480 (4,970–17,385), 46.6%	12,431±5,593 (6,730–25,220), 45.0%	11,216±2,852 (7,996–17,302), 25.4%
Thursday	9,038±3,113 (5,120–14,895), 34.4%	11,332±5,677 (5,723–23,164), 50.1%	11,364±2,213 (7,451–13,538), 19.5%
Friday	6,579±2,577 (1,915–10,214), 39.2%	10,222±6,660 (5,396–26,053), 65.2%	11,230±3,602 (6,268–18,382), 32.1%
Saturday	7,383±3,020 (3,313–13,195), 40.9%	6,871±6,303 (1,939–21,620), 91.7%	7,914±3,715 (2,508–14,069), 46.9%
Sunday	7,541±1,930 (5,659–11,720), 25.6%	6,651±5.920 (2,545–21,023), 89.0%	6,256±3,062 (2,653–12,639), 48.9%
		Females	
Monday	7,854±2,763 (3,176–11,346), 35.2%	8,381±1,467 (6,324–10,586), 17.5%	8,629±1,716 (5,928–10,965), 19.9%
Tuesday	7,633±3,161 (3,890–11,901), 41,4%	6,356±0,800 (5,217–7,003), 12.6%	8,701±1,793 (6,744–11,168), 20.6%
Wednesday	7,344±3,989 (2,248–13,899), 54.3%	7,460±1,507 (5,090–8,936), 20.2%	8,317±3,295 (5,669–14,524), 39.6%
Thursday	9,492±3,199 (5,576–14,946), 33.7%	7,083±1,641 (4,411–9,463), 23.2%	9,060±2,520 (6,107–12,540), 27.8%
Friday	9,676±2,900 (7,000–14,450), 30.0%	6,356±1,309 (4,422–8,271), 20,6%	9,573±2,388 (6,597–12,800), 24.9%
Saturday	6,906±1,637 (5,244–9,066), 23.7%	3,927±0,744 (2,807–4,842), 19.0%	5,387±1,543 (3,537–7,069), 28.6%
Sunday	9,187±4,763 (4,623–15,033), 51.8%	3,759±1,277 (1,481–4,922), 34.0%	3,692±1,294 (2,334–5,702), 35.0%

*Note: M – arithmetic mean; SD – standard deviation; Max – maximal; Min – minimal; V% – coefficient of variance.

($p = 0.002$): 20 % of total variation was explained with gender category (Table 3). Contrary to this, differences between the results measured in three corresponding seasons (autumn, winter, and spring) were much smaller ($p = 0.307$), with only 4.4 % of total variation. Results of the analysis showed moderate interaction between these two main factors (gender and repeated measures variations): $p = 0.068$, Q = 10.5 %. But the greatest part of variation was appeared because differences between days of week (in site variation): Q = 65.1 %.

One-way ANOVA was used to determine differences between samples grouped according days of weeks (Table 4).

Table 3. Summarised results of two-ways ANOVA regarding steps/day count

Source of variation	SS	df	MS	F*	p	Q%
Gender	36,078,841	1	36,078,841	11.085	0.002	20.0
Seasons	7,949,693	2	3,974,846	1.221	0.307	4.4
Interaction	18,866,358	2	9,433,179	2.898	0.068	10.5
In site	117,167,181	36	3,254,644			65.1
Total	180,062,073	41				100.0

*F(1, 36, 0.05) = 4.113; F(2, 36, 0.05) = 3.259.

Student t-test was applied in evaluation of differences between means of seasons and days of week. Strong significant difference between counts of steps during days of week for boys ($p = 0.006$) and smaller significant difference for girls ($p = 0.052$) were discovered with corresponding parts in the total variation (62.5 and 46.0 %). The same significant differences were discovered between mean counts in seasons ($p = 0.053$, 0.037) with corresponding parts in the total variation (14.5, 22.8 %). Rather significant variations of interaction between days of week and mean season results took place for boys (Q = 23.0 %) as well for girls (Q = 31.1 %).

There were significant differences steps/day counts during weekdays and weekend showed by students studied together ($p = 0.0001$); and separately by males ($p < 0.0001$) and females ($p = 0.031$).

Pedometer-determined physical activity for children varied during the academic year in different ways regarding their gender. Males showed monotone increase between seasons from autumn to winter (20.8%) and from winter to spring (7.5 %) (Figure 2). Females showed significant decrease from autumn to winter (25.4%) and increase from winter to spring (23.2%). The students together showed decreasing from autumn to winter (6.5%) and increasing from winter to spring (13.7%).

Table 4. Results of one-way ANOVA with repeated measures for males (upper) and females (lower)

Source of variation	SS	df	MS	F*	p	Q%
Days	45,559,122	6	7,593,187	5.445	0.006	62.5
	32,739,523		5,456,587	2.958	0.052	46.0
Seasons	10,563,882	2	5,281,941	3.788	0.053	14.5
	16,252,169		8,126,085	4.405	0.037	22.8
Interaction	16,733,538	12	1,394,461	–	–	23.0
	22,134,998		1,844,583			31.1
Total	72,856,541	20	–	–	–	100.0
	71,126,691					

*F(6, 12, 0.05) = 2.996; F(2, 12, 0.05) = 3.885.

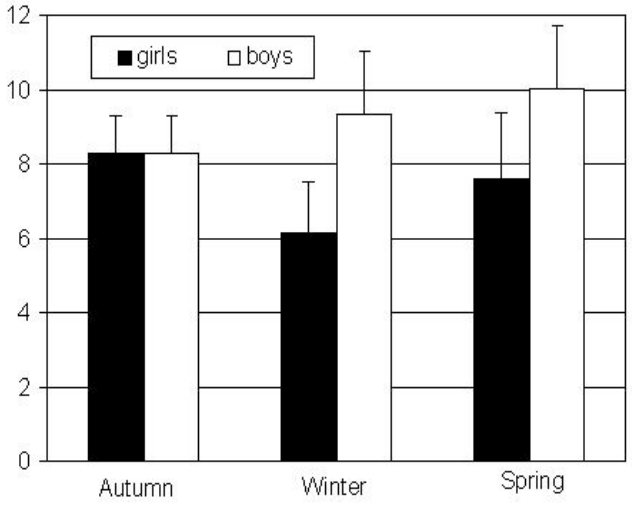

Fig. 2. Thousands of steps/day (M + SD)

Discussion

According to the aim of this research, a model of interaction between steps/day counts regarding genders, seasons of a year, and days of week has been created (see Introduction section). The model of interaction derived in the research could be useful in realising a structure of variation steps/day variation depended from genders, seasons of a year, and days of week. In many scientific publication, variations between measured steps were studied basing on differences between mean values ignoring interactions between sources of dispersion (Busheva, 2016; Mears et al., 2019) etc. Investigation of steps/day counts in the frames of the model made possible to discover significant interactions between genders – season variations ($p < 0.068$). Corresponding relative part in a total variation (10.5 %) is two times greater than relative part of the season's variation (4.4 %) (see Table 3).

Comparing results of our research regarding pedometer determined physical activity in children, one can notice that boys were significantly overhead in the physical activity of girls (see Table 2). For example, in winter this difference was on an average 3,146 steps/day, $p < 0.001$) that corresponds with results has been gotten in many well-known investigations (President's Council, 2016). Furthermore, according to the evaluation norms, steps/day counts in boys are about 3,000 higher, than in girls (see Table 1).

The results based on this model corroborate well-known results about significant difference ($p < 0.05$) between pedometer determined physical activity of children in week days and weekends (Sukharev et al., 1998). Further more, this difference is much more significant for boys ($p < 0.001$) than for girls ($p < 0.031$). Dispersion of pedometer determined physical activity between participants was found as great (V > 20 %) in boys as well in girls from day to day, season to season that agrees with data measured in the frames of different researches (Al-Khadairy et al., 2017).

Measurements conducted during academic year confirmed validity and reliability of the Fitness tracker Fitbit Charge for monitoring of pedometer determined physical activity in children, however, in segments where sedentary time dominates (e.g. academic classes), a research-grade accelerometer should be preferred (Mooses et al., 2018).

Because mathematical part of the model of interaction between steps/day counts is based on ANOVA, corresponding calculations were realised in MS Excel packet of analysis. The same calculations are possible using other popular in Sport Sciences statistical packets: SPSS Statistics (Analyze > ANOVA > Compare Means > One-Way ANOVA, Analyze > GLM Repeated Measures > ANOVA) and Statistica StatSoft (Statistics > ANOVA / MANOVA > Factorial ANOVA) (IBM, 2017; Dell, 2017).

Evaluation of schoolchildren's daily motor activity has helped to find out that on average, children make less steps per day than the minimum allowable rate (Martin et al., 2018), which indicates hypokinesia: the boys' index is 9,224 and the girls' – 7,370. The data we obtained are slightly lower than those presented by other scholars, which indicates a sedentary lifestyle of schoolchildren. In addition, according to previously obtained data, more children (70.0%) do not participate in sports, and most of the children spend their free time inactively (computer games, watching TV) (Karbasi et al., 2018).

It was found that the level of motor activity among boys is higher during every season (autumn, winter, spring), so boys are more active than girls. Trost et al. (2002) also observed in their studies the differences between boys and girls in activity, stating that boys perform more steps per day than girls. This observation highlights the need to place particular emphasis on girls' physical activity.

According to our data, the average number of steps during weekdays (10,072 steps/days for boys and 8,128 steps/days for girls) was higher than during weekends (7,103 steps/days for boys and 5,476 steps/days for girls). Previous studies presented by various countries have found similar trends observed among Swedish, Australian, and American (Vincent et al., 2003), New Zealand (Remmers et al., 2017), Japanese (Ishii et al., 2015) junior schoolchildren.

In the experimental studies Al-Khudairy et al. (2017) indicated a downward trend in motor activity over the weekend relatively to the children's age, the older the less. But motor activity increased over the weekend considering the socio-economic status of the family. Such a difference was not observed on weekdays. They also emphasized that the activity level of overweight children was significantly lower on weekdays and weekends compared to normal-weight children

Thus, not only approaches related to school physical education but also extra-curricular physical education time is important to help increase the daily motor activity of students (Vos et al., 2011). Parents should pay more attention to physical activity and active leisure during days off when the children have less workload. The best way is to demonstrate personal positive attitude towards exercising. This, in its turn, will encourage students' interest and their involvement in the physical activity in order to preserve and promote their health (Bodnarchuk & Zanevskyy, 2011).

Conclusions

The research hypothesis of this paper about significant interactions between steps/day counts regarding genders, seasons of a year, and days of week while testing pedometer determined physical activity has been convincingly approved. Corresponding model of pedometer determined physical activity has been created using one-way ANOVA for repeated measures that made possible to determine differences between samples grouped according days of weeks. The two-ways ANOVA could be recommended to determine differences between samples grouped according gender and season relatively days of weeks.

Highlights

During evaluation of physical activity in children based on steps/day counts, interaction between gender, season, and day of week should be taken into consideration.

The main scientific result of this research is discovery of interactions between steps/day counts regarding genders, seasons of a year, and days of week, and creating the quantified model of testing pedometer determined physical activity in children.

The use of well-known MS Excel computer packet as a mathematical instrument of the model of pedometer determined physical activity make possible to use this model for teachers of physical culture and coachers which are not familiar with mathematical modelling.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding this research.

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ПЕДОМЕТРИЧНА МОДЕЛЬ ФІЗИЧНОЇ АКТИВНОСТІ ДІТЕЙ В ПОЧАТКОВІЙ ШКОЛІ

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Мета дослідження. Визначення кількості кроків протягом дня є популярним та ефективним методом тестування фізичної активності дітей. Мета дослідження – створити модель взаємодії денної кількості кроків відносно статі, пори року та днів тижня.

Матеріали і методи. Загалом 74 учня (38 хлопців і 36 дівчат) четвертих класів трьох шкіл промислового міста було залучено до вимірювань. Стан здоров'я усіх школярів був добрий, й на уроках фізичної культури вони займалися за загальною програмою. Кількість кроків протягом дня визначалася з використанням фітнес крокоміра. Дослідження проведено протягом навчального року за три тижні (по одному тижню восени, взимку й навесні). Дисперсійний аналіз було застосовано для визначення різниці результатів між групами за днями тижня.

Результати. Було виявлено статистично істотну різницю між кількістю кроків протягом дня у хлопців (p = 0,006) і менш істотну – у дівчат (p = 0,052) із відповідною часткою у загальній варіації (62,5 і 46,0 %).Така ж суттєва різниця мала місце між результатами по сезонах року (p = 0,053; 0,037) із відповідною часткою у загальній варіації (14,5; 22,8 %). Досить істотна варіація по днях тижня й середньо сезонними результатами мала місце як для хлопців (23,0 %), так і для дівчат (31,1 %).

Висновки. При оцінюванні фізичної активності дітей необхідно враховувати взаємодію між кількістю кроків протягом дня відносно статі, пори року та днів тижня.

Ключові слова: фізичне виховання, школярі, четвертий клас, тестування, моделювання.

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