

The effect of replacing sedentary behavior by different intensities of physical activity in body composition: a systematic review

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ABSTRACT

Introduction: The isotemporal substitution model (ISM) is a statistical approach that estimates the effects of replacing, in minutes, a block of physical activity or sedentary behavior by another block with different intensity. Previous studies have used the ISM to evaluate the effect of different isotemporal substitutions on body composition. Thus, the ISM can contribute to the understanding of changes in body composition related to distinct lifestyles and, hence, guiding future recommendations for maintaining and/or improving body composition. **Objective:** To review the effect of replacing sedentary behavior by physical activity on body composition change analyzed through ISM. **Methods:** Original articles in English were identified from searches in PubMed and *Periódicos Capes* databases. The search was carried out by two researchers. Last search was performed in October 2020. **Results:** A total of 17 included articles, which evaluated different applications of ISM in relation to body composition change, mostly obtained by BMI and body fat. The physical activity was mainly assessed by using an accelerometer. Several methodological differences among the included studies limited comparisons between findings, including the sample profile and cut off points for physical activity. **Conclusion:** Among the studies that evaluate the effect of replacing sedentary behavior for different intensities of physical activity through ISM, replacing sedentary behavior by moderate-to-vigorous physical activity presented a more consistent effect in body composition change in comparison to replacement by other physical activity intensities, even for small blocks of time (five minutes).

Keywords: method; body composition; sedentary behavior; physical activity.

INTRODUCTION

The isotemporal substitution model (ISM) was developed after publication of Willett's nutritional studies¹. These studies investigate total energy intake, highlighting the importance of these findings for nutritional epidemiology^{2,3}. Mekary *et al.*¹ applied these modeling methods to physical activity epidemiology. Thus, the authors detailed the physical activity pattern (type and amount of time spent in each activity) to elaborate a statistical approach known as ISM.

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Therefore, ISM is defined as a strategy to estimate the effects of replacing a block of time spent in physical activity for another with the same amount of time¹. Regarding the ISM, the most used blocks were time spent in watching television, slow and fast walk, running, and other activities (swimming, bicycle riding, aerobics, playing tennis, climbing stairs)¹. Time spent in these activities generate coefficients to total physical activity¹.

Since it is not possible to add minutes in the day to perform effort and the duration of a day is finite, other variables may decrease for increasing time in such activities⁴. Thus, the ISM was adjusted for total activity and has been developed to minimize limitations inherent to the method, receiving the name of compositional isotemporal substitution or compositional data analysis⁵. Recently, ISM includes time spent in sleep and daily time of 24h⁵.

Although the 150 minutes of moderate-to-vigorous physical activity (MVPA) per week were the minimum recommended to be considered physically active⁶, one in each four adults does not meet the criteria and inactivity has been growing, especially in children and elderly⁶⁻⁸. Physical effort, if done regularly, can prevent and bring benefits regarding chronic diseases, such as cancer, diabetes and cardiovascular diseases⁹. In contrast, sedentary behavior is associated with worse quality of life in children and adolescents¹⁰ and increased risk of all-cause mortality in older adults¹¹, which reinforces the importance of establishing goals and recommendations, not only for encouraging physical activity, but also for preventing and reducing sedentary behavior. Therefore, ISM can contribute to development of behavior-change interventions.

At first, the ISM included relative values. However, the percentage of physical exercise lacks clarity, mainly because what means 5% of vigorous physical activity to someone may not be to another¹². Recently, ISM uses absolute values of physical activity (i.e., block of time spent in each activity in minutes instead of percentage) to be more “touchable” and, hence, to facilitate the interpretation. Furthermore, physical activity guidelines use minutes as a unit for recommendation¹².

Mekary & Ding¹² suggests that ISM can be a golden standard model for physical activity epidemiology. Additionally, ISM is considered accurate to estimate the effect of replacing a block of time spent in one type of activity by another with the same amount of time. Therefore, ISM can be used to test hypothetical lifestyle interventions based on substitution of sedentary behavior by physical activity, for example.

Body composition can be obtained by anthropometric measures. It allows to evaluate and predict the performance, health and survival in children and adults, as well as to identify social and economic equity and inequity. On the other hand, the interpretation of anthropometric measures depends on the evaluated population¹³, for example, waist circumference is not accurate to cardiovascular disease in pregnant women or in post-partum

and body mass index is not accurate to elite athlete's evaluation. Therefore, it is recommended to combine one or more measures to minimize these aforementioned limitations^{13,14}. Moreover, sedentary behavior and physical activity can be obtained by subject self-report through questionnaires¹⁵, or objectively measured through pedometers or accelerometers^{16,17}.

The purpose of the present study was to identify, review and synthesize studies that investigate whether replacing sedentary behavior by the same amount of time of different intensities of physical activity determine body composition change, when analyzed through ISM. Secondly, we aimed to provide basis for development of behavior change interventions.

METHODS

Study design

This systematic review was guided and reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)¹⁸ statement.

Literature search

The literature search was performed for English language literature published and indexed until May 2019 in databases of PubMed and *Periódicos Capes* that include publications indexed in Medline/PubMed (NLM), Scopus (Elsevier), Science Citation Index Expanded (Web of Science), OneFile (GALE), PMC (PubMed Central).

The search strategy was based on keywords: “isotemporal substitution model” AND “physical activity” AND “body composition”. Table 1 shows the search strategy. The updated search was performed on October 8, 2020.

The search was conducted by a single researcher (MAS). The reviewer screened and selected the eligible articles regarding inclusion and exclusion criteria. The full texts were also evaluated in order to verify the eligibility criteria. Another reviewer (TLVDPO) checked the potential citations for completion and accuracy.

Table 1: Search strategy and number of founded articles in each database.

Step	Terms
(1)	Isotemporal Substitution Model
(2)	Physical Activity
(3)	Body Composition
(4)	#1 AND #2 AND #3
Pubmed	(“isotemporal substitution model”[All Fields]) AND (“physical activity”[All Fields]) AND (“body composition”[All Fields]) AND English[lang]) 18 articles found
<i>Portal de Periódicos Capes</i>	(isotemporal substitution model) AND (physical activity) AND (body composition) 81 articles found

Disagreements related to the eligibility of the studies were discussed. References of the relevant articles were also searched.

Eligibility criteria

The eligibility criteria were studies that investigated whether replacing sedentary behavior for the same amount of time of physical activity at different intensities determined body composition change analyzed through ISM.

Regardless of population, the body composition change must be estimated as an outcome of the ISM. Additionally, physical activity should be categorized, at least, in sedentary behavior or sedentary time, light-intensity physical activity (LIPA) and moderate-to-vigorous physical activity (MVPA). However, articles that reported and/or only used patterns of sedentary behavior

(sedentary bouts and breaks) in ISM analysis were not included, as well as articles that not described physical activities according to intensities (LIPA, moderate physical activity, vigorous physical activity, MVPA or very vigorous physical activity).

According to the chosen theme, there was no restriction on articles publication data. Only articles in English were included.

Data extraction and synthesis

One reviewer (MAS) performed the screening of titles and abstracts to identify potentially eligible studies, as well as the full-texts. Then, the reviewers (MAS and TLVDPO) extracted data from included studies and proceeded with a qualitative synthesis, as follows: author and year, study design, sample size, objective, ISM and main findings (Table 2). We also detailed the

Table 2: Description of the selected studies on study design, sample size, isotemporal substitution model and main findings.

Author, year	Study design	Sample size	Objective	ISM	Main findings
Leppanen et al. 2016 ²⁴	Cross-sectional study, population-based trial was a two-arm, parallel design randomized controlled trial.	307 children	Investigate PA intensity and physical inactivity, with accelerometer, and association with fatness and fitness in Swedish 4 years.	5 minutes SB to LPA 5 minutes SB to MPA 5 minutes SB to VPA	↓FFMI ↓FFMI ↓FFMI
Varela-Mato et al. 2017 ²¹	Cross-sectional surveillance study was undertaken at a large UK-based transport company from the East Midlands	159 drivers (58% of this workforce) with varied working hours drivers	First objective was to map the behavior of trucking around UK in terms of time spent in non/sedentary behavior during non-workdays and non-work hours. Second objective was to examine cardio metabolic and mental health markers	30 minutes SB to standing 30 minutes SB to sleeping on working days 30 minutes SB to sleeping on non-working days 30 minutes SB to MVPA on working days	↓WC/ ND BMI ↓WC/ ↓BMI ND WC/ ↓BMI ↓WC/ ↓BMI
Aggio et al. 2015 ²⁵	Cross-sectional study where participants were drawn from schools in Camden, London	4505 with 9 years old participants	To use MSI to investigate the effect of replacing a certain intensity in PA with another at the same time in the health and fitness of young people	60 minutes SB to LPA 60 minutes SB to MVPA	ND Body Fat ↓ Body fat
Danquah et al. 2018 ²²	Cross-sectional (1-month follow-up) and longitudinal (3-months follow-up)	>18 years with >30 hours of work per week and longer sitting 317 participated	It is a cohort study with interventions and a control group to compare the effects of exchanging an hour sitting for standing at work hours, for ISM transversely and longitudinally	60 minutes sitting to stand transversely and longitudinally	↑Fat-free mass ↓fat mass ↓ WC
Pozo-Cruz et al. 2017 ²⁶	Random data from the cross-sectional National Survey of Children and Young People's Physical Activity and Dietary Behaviors in New Zealand (2008/09)	2503 children and young people (5-24) by blocks	They aimed to model the impact of sleep, SB and PA on BMI among children and youth (5 ± 24 years) using data from a nationally representative survey from New Zealand	60 minutes (5-19 years) SB to sleep or LPA or MVPA 30 minutes (20-24 years) to sleep or LPA or MVPA	↓ BMI ↓ BMI
Boyle et al. 2017 ³⁵	Cross-sectional sample of breast cancer survivors in Australia	274 completed the study and the sample remained 238 with complete data	Use ISM to investigate interdependent associations of self-reported sleep and objective measurement of sedentary time, BP with WC and BMI in breast cancer survivors	30 minutes of prolonged sedentary time, breaks in sedentary time, LPA or in MVP. 30 minutes of prolonged sedentary time to sleep	↓ BMI ↓ WC ND BMI/ ND WC
Leppanen et al. 2017 ¹⁴	This utilized baseline and 12-month follow-up data from the MINISTOP trial collected between 2014 and 2016. It was a two-arm, parallel design randomized controlled and population-based trial	315 healthy Swedish 4-year-old children	To investigate longitudinally associations of PA with SB and body composition and physical fitness in the health of Swedish children aged 4.5 and 12 months later, as a follow-up to the previous cross-sectional study. Additionally,	5 minutes SB to MVPA	ND BMI/ ND FFMI/ ↓FM ↓FMI

Continue...

Table 2: Continue.

Author, year	Study design	Sample size	Objective	ISM	Main findings
			studying whether changes in PA and SB between 4.5 and 5.5 years are associated with changes in body composition and physical fitness		
Collings et al. 2016 ²⁷	This cross-sectional investigation used baseline data from the Physical Activity and Nutrition in Children study, a PA and diet intervention in the city of Kuopio, Finland	410 children (aged 7.6 ± 0.4 years)	To examine the spectrum of PA intensity and establish a minimum PA intensity associated with low adiposity and high cardiorespiratory fitness in middle childhood, and compare the effects of time reallocation between SB and PA intensities on the same findings	10 minutes SB to LPA	↓FM ↓FMI
				10 minutes SB to MPA	↓FM ↓FMI
				10 minutes SB to VPA	↓FM ↓FMI
Collings et al. 2017 ²³	Data from a range of studies in Born in Bradford birth cohort study and research program including the Healthy and Active Parenting Program for early Years feasibility randomized controlled trial, the Born in Bradford observational cohort study, the Preschoolers in the Playground pilot cluster, and the Learning Environment and Active Play observational study.	333 children between 11 months and 5 years of age.	Cross-sectional investigations of BP in volume and intensity distributions, and SB, with adiposity in ethnic samples from South Asian and English children from a city in northern England.	20 minutes SB to LPA	↓BMI ↓WC ND skinfold thickness
Dumuid et al. 2018 ³¹	Participants were from four study sites (Australia, Canada, United Kingdom and Finland) included in the larger cross-sectional 12-nation International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE)	1728 children aged 9-11 years	First study to estimate the adiposity difference associated with time reallocation between daily behaviors in children using isotemporal and compositional substitution model method, comparing findings and obtained from the two approaches	30 minutes of SB to sleep	↑Body fat
				30 minutes of SB to LPA	↓Body fat
				30 minutes of SB to MVPA	↓Body fat
Loprinzi et al. 2015 ²⁸	Cross-sectional utilized baseline of three years follow-up data from the National Health and Nutrition Examination Survey trial collected between 2003 and 2006	2856 children	Secondary analysis of NHANES 2003-2006 accelerometer data, using new ISM method for associations between SB, LPA and MVPA in children and adolescents in the USA, with body composition using dual X-ray absorptometry (DEXA), BMI, WC, and skinfolds thickness Patterns of behavior, movement, associations with adiposity milestones in US children, and adolescents	60 minutes SB to LPA or MVPA	↓BMI ↓WC ↓Skinfold thickness ↓ body fat
Falconer et al. 2015 ¹⁹	Cross-sectional secondary data analysis from baseline data collected as part of the Early Activity in Diabetes study, a randomized controlled trial of physical activity and diet in the early management of type 2 diabetes around South West of England	593 newly diagnosed type 2 diabetes were recruited	The aims of this study were therefore to use isotemporal methods to examine the substitution effects of the different activity intensity types on metabolic health by artificially displacing a fixed duration of one activity intensity with a fixed duration of another	30 minutes SB to short SB	ND BMI/ ND WC
				30 minutes SB to LPA	↓ BMI ↓WC
				30 minutes SB to MVPA	↓ BMI ↓WC
Petersen et al. 2017 ³³	Data are from the Inuit Health in Transition study from 2005–2010, a countrywide cross-sectional health survey in Greenland	1497 Inuit Greenlanders	First, to examine how objectively measured PA energy expenditure was related to BMI, waist circumference, visceral fat (VAT) and subcutaneous abdominal adipose tissue (SAT). Secondly, to examine how reallocating time spent at various intensities and bout patterns of PA was associated with abdominal fat distribution in a population-based study of adult Inuit in Greenland.	1-hour SB to LPA	↓ BMI ↓WC ↓ Visceral fat ↓Sub-cutaneous fat
				1-hour SB to MPA	↓ BMI ↓WC ↓ Visceral fat ↓Sub-cutaneous fat

Continue...

Table 2: Continue.

Author, year	Study design	Sample size	Objective	ISM	Main findings
Curtis et al. 2020 ³⁶	This study used cross-sectional data from the baseline assessment of a randomized controlled trial, evaluating the effectiveness of a Health Physical Activity Intervention, around in Australia	430 participants.	This study therefore aimed to examine the association of time-use compositions with PA and mental well-being in a sample of young and middle-aged adults To examine whether time-use composition was associated with BMI; PA and mental health; and symptoms of depression, anxiety, and stress and use the compositional isotemporal substitution model to examine how reallocations between sleep, SB, LPA, and MVPA were associated with these PA and mental well-being variables	15 minutes SB to LPA	↓ BMI ↓ z-BMI
				15 minutes SB to MVPA	↓ BMI ↓ z-BMI
Panades et al. 2019 ³⁴	The PREDIMED-Plus study is a 6-year ongoing multicenter, randomized clinical trial, with two intervention arms for the primary prevention of cardiovascular dysfunction in Spain	2189 women	To explore cross-sectional associations between inactive time and cardio-metabolic risk factors; and to assess the impact of replenishment 30 min per day of inactive time by 30 min of LPA, MVPA and time in bed on markers of cardio-metabolic health	30 min SB to LPA	↓ BMI ↓ body fat ↓Visceral fat
Oviedo-Caro et al. 2020 ³²	Exploratory cross-sectional study	130 healthy pregnant women aged 18-45 years	The aims of this study are (a) to assess the associations between the activity composition and adiposity and CRF during mid pregnancy and to investigate how time reallocations between activity behaviors are associated with favorable or unfavorable adiposity and CRF	15 to 30 minutes SB to LPA or MVPA	↓ BMI ↓ sum of skinfold thickness ↓FMI
Jones et al. 2020 ²⁹	The present study is a secondary analysis of data collected in 2015 for the Physical activity, Exercise, Diet, And Lifestyle Study. It was a cross-sectional survey study, which invited all schools with at least in the greater Dunedin (New Zealand) area to participate	465 children aged 9–11 years participated	They aimed at assess associations of accelerometer-measured SB with adiposity and fitness in children aged 9–11 years and whether associations varied when total ST was separated into long bouts (≥10 min) and short bouts of ST (<10 min)	30 minutes SB to LPA, and MVPA	↓ adiposity
Tan et al. 2020 ³⁰	This prospective study was drawn from a national school-based healthy lifestyle intervention program, which was conducted from September 2013 to June 2014 in China As a multicenter randomized study, this study was undertaken with a multistage cluster sampling method, selecting 94 elementary, middle, and high schools	15,100 participants 7–18 years	The purpose of this current study was to investigate the prospective association of VPA, MPA, walking and sedentary time with the changes in weight status, by applying ISM regression analysis	30 minutes of SB to walking	ND BMI/ ND z-BMI/ ND weight
				30 minutes of SB to LPA	ND BMI/ ND z-BMI/ ND weight
				30 minutes of SB to MPA	ND BMI/ ND z-BMI ND weight

PA: physical activity; LIPA: light-intensity physical activity; MPA: moderate physical activity; VPA: vigorous physical activity; MVPA: moderate to vigorous physical activity; SB: sedentary behavior; ISM: isotemporal substitution model; CRF: cardiorespiratory fitness; FMI: fat mass index; FFMI: fat free mass index; FFM: fat free mass; BMI: body mass index; WC: waist circumference; ND: no difference.

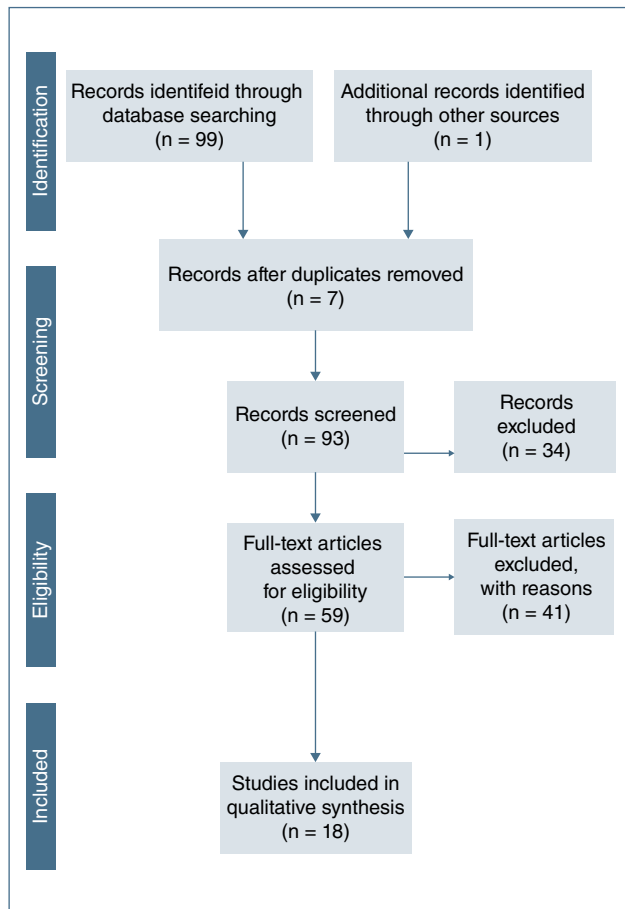


Figure 1: Flow diagram resuming the screening, selection, eligibility criteria and studies included on this review.

assessment of physical activity, sedentary behavior and body composition.

RESULTS

Studies characteristics

After duplicates were excluded, a total of 67 articles remained for screening and selection. The eligibility criteria were presented in a flow diagram (Figure 1).

We excluded articles that did not use the ISM as previously described¹⁹ or analyzed the substitution by using data as percentage instead minutes¹, had other outcomes in the ISM differently than body composition data²⁰ and did not classify physical activity intensities¹.

Therefore, we included 18 original articles that used ISM to estimate the body composition change after replacing one block of time of activity by another with the same amount of time. After analyzing the references of included studies, an additional article was included in this review, as can be seen in Figure 1.

Most of the original articles included were cross-sectional studies. They commonly use ISM in association with the partition model and single behavior model.

We were not able to perform a meta-analysis due to methodological heterogeneity observed in the included studies, especially regarding the amount of time replaced that varies from five to sixty minutes and the cut points used to obtain sedentary behavior and physical activity category.

Sample profile

The sample of the included studies was heterogeneous, including truck drivers²¹, office workers²², children^{14,23-31}, healthy pregnant women³², Inuit Greenlanders³³, newly diagnosed type 2 diabetes¹⁹. However, the sample was mostly composed of white subjects and from the north hemisphere^{14,19,24,25,27,30,32-34}. Two studies were made with New Zealanders children^{26,29} and one study with breast cancer survivors³⁵.

Physical activity and sedentary behavior assessment

Physical activity and sedentary behavior were mainly assessed by using accelerometry. Some studies used cut-points to determine the intensities in physical activity in Metabolic Equivalent of Task (MET)^{26,27,33}, while other studies used counts^{19,23,25,26,28,29,31,35,36} or steps²¹, both by minutes. The studies used Freedson's or Evenson's calibration for accelerometer assessment³⁷⁻³⁹.

One study used the effort perception scale coming from International Physical Activity Questionnaire - Short Form (IPAQ-SF)³⁰.

Body composition

The body composition was obtained by using bioimpedance^{21-23,25,27,29,31,32}, plethysmography^{14,24}, anthropometry^{19,21,32-36,22,23,26-31}, ultrasound system³³, and dual-energy X-ray absorptiometry^{27,28,34}.

Isotemporal substitution model

The blocks replaced varied between five²⁴ to sixty minutes^{22,25,28,33}. Regardless of block duration, replacing blocks of sedentary behavior for blocks with the same amount of time of MVPA was associated with body composition change, mainly for body fat percentage and waist circumference^{14,21,35,23-29,33}.

DISCUSSION

We aimed to identify, review, and summarize studies that investigate whether replacing sedentary behavior by physical activity at different intensities determines body composition change by using a specific statistical approach. Physical inactivity is a worldwide public health problem due to contemporary

lifestyle⁴⁰, but also because more than half of the population is engaged in activities based on sedentary behavior²⁰. Sedentary lifestyle is associated with deleterious health consequences as greater risk for all-cause mortality, cancer incidence and mortality, and cardiovascular diseases⁶. Among the included studies, even the smallest replacement of sedentary behavior (five minutes)¹⁴ by any physical activity category can result in body composition change, according to the ISM. As expected, when high block of time is replaced or high intensity physical activity category, high body composition change, especially for adiposity values.

Although accelerometer-based sedentary behavior and physical activity was the main assessment, the cut-points to determine physical activity as categories differed according to the included studies, which can be explained by the sample's profiles. As already known, there specific cut-points^{37,41-44} that have been validated for different subjects from children to older adults, including clinical groups.

The blocks of time replaced vary according to the included studies. Valera-Malato²¹ used blocks of 30 minutes to match with physical activity guidelines, while Petersen *et al.*³³, Loprinzi *et al.*²⁸, Aggio *et al.*²⁵ replaced blocks of 60 minutes, respectively sedentary time replaced by LIPA and moderate physical activity, as well as LIPA with MVPA³³, sedentary behavior by another PA category²⁸, sedentary behavior by LIPA and MVPA²⁵. Standardizing the amount of time for analyzing the composition of time spent on different activities could facilitate the comparison of results between studies and favor a more precise basis for developing strategies to promote physical activity and prevent sedentary behavior. In contrast, in other studies^{14,23,24}, there's a tendency to replace small blocks of time to reproduce small lifestyle changes, especially decrease in sedentary behavior and, hence, reinforce and stimulate a change in physical activity daily level in addition to meeting the MVPA recommendations³¹.

In the present systematic review, we focused on identifying the effect of replacing sedentary behavior and/or LIPA by another physical activity category in body composition change, regardless of a specific population. However, obesity among other chronic non-communicable diseases can be observed not only in a unique population profile, but as a worldwide phenomenon⁴⁵. In addition, obesity is a major public health problem due to alarming growth in children and adolescents⁴⁶⁻⁴⁸, adults⁴⁹⁻⁵⁰, and elderly⁵¹. Therefore, we take into account these data to draw our search strategy and eligibility criteria.

Regular practice of physical exercises, in turn, is a prevention key of these diseases associated with a diet based on fresh or minimally processed foods^{45,52}. However, truck-drivers profile, for instance, is part of a group resistant to health interventions, highlighting the need for engagement in MVPA²¹. Also, the potential of ISM contribution to design interventions is reinforced since the model can investigate the replacement of different amounts of time and physical activity categories.

Moreover, Loprinzi's study²⁸ emphasizes inherent changes in the sample profile. The progressive decrease in physical activity and increase in sedentary behavior with ageing can be explained by changes in the dopaminergic system, or by social conventions (e.g., dating, taking a driver's license). Other limitations affect older adults (above 65 years) as physiologic capabilities, diseases. This profile is least physically active of all age groups^{6,53}. Thus, future studies should also investigate sedentary behavior, LIPA and adiposity with aging.

Both Collings' studies^{23,27} point out that it is time for public health to look at the concept of dose-dependent relationships of physical activity. If time is limited for physical exercise, or greater spontaneous movement, high intensity activities interventions offer an opportunity to benefit body composition and others health patterns. Therefore, the ISM is an easy method to evaluate possibilities of dose-dependent interventions that can be widely explored in future research.

Sedentary behavior is already studied and is largely associated with all-cause mortality, mental health and quality of life^{10,54,55}. But sedentary behavior itself is poorly investigated in studies with ISM. Among the included studies, only one study evaluated replacement of sitting time by standing²². The accelerometry must also be discussed since some devices were not able to differentiate the body position. Previous review about health-related findings from the ISM raises a question regarding the difference in sedentary behavior, including standing and sitting time and the effect on health⁵⁶. However, the literature still requires taking into account this ambiguity about sedentary behavior. In Danquah's²² study demonstrated a small but significant change in fat-free mass, fat mass and waist circumference when replacing sitting time by standing.

The methods of body composition assessment were described in Table 3. Among all the biases of each method, the ones with the highest risk of error are self-reported weight and height. It is important to mention that Pozo-Cruz²⁶ study used self-reported waist circumference, although provided instruction of how to measure via phone call³⁵.

Different types of accelerometer models and its respective use (i.e., wrist and waist) difficult to standardize the procedures. Also, the device being waterproof or not interfere in physical activity measurement, particularly because water activities in swimming pools or sea depend on subjective reports.

Another unexplored bias was the season of the year of data collection. Only two^{21,23} of the included articles raised this issue as necessary, whereas behavior can be different depending on the temperature, sunrise and sunset time, and other seasonal aspects.

The main limitations were related to the cross-sectional design, which does not indicate causality of the findings, the use of non-waterproof accelerometer, ceasing water activities data, and, lastly, the cut-points definition for physical activity (as shown in Table 4). Effects can be overestimated in a cross-sectional study due to residual confounders. According to the eligibility criteria,

Table 3: Characteristics of the included studies, physical activity and sedentary behavior and body composition assessment and additional measures.

Study	Physical activity and sedentary behavior	Body Composition	Additional measures
Leppanen et al. 2016 ²⁴	Triaxial accelerometer	Plethysmography and waist circumference	Cardiorespiratory exercise testing; handgrip strength; PREFIT fitness test battery
Varela-Mato et al. 2017 ²¹	Waterproof accelerometer	Height (stadiometer); waist-to-hip ratio; bioimpedance and BMI	Blood pressure; Hospital Anxiety and Depression Scale; FBG, TGs, HDL-C, LDL-C, TC
Aggio et al. 2015 ²⁵	Triaxial accelerometer	Bioimpedance (fat body mass as percentage)	Dynamometry; sit and-reach test using a standard sit-and-reach box; peak flow meter.
Danquah et al. 2018 ²²	Waterproof accelerometer	Bioimpedance (fat free mass and fat body mass as percentage); Waist circumference	-
Pozo-Cruz et al. 2017 ²⁶	Accelerometer	Height and weight, BMI	-
Boyle et al. 2017 ³⁵	Accelerometer	Self-reported height, weight, and waist circumference.	-
Leppanen et al. 2017 ¹⁴	Triaxial accelerometer	Plethysmography	PREFIT fitness test battery
Collings et al. 2016 ²⁷	Heart rate and movement sensor	Height (stadiometer) Bioimpedance (weight) score-z BMI, DEXA	Maximal cycle ergometer test
Collings et al. 2017 ²³	Accelerometer	Height and weight (stadiometer) and bioimpedance; score-z BMI; waist circumference	-
Dumuid et al. 2018 ³¹	Accelerometer	Bioimpedance (body fat mass as percentage); height (stadiometer); score-z BMI;	Sociodemographic factors reported by parents
Loprinzi et al. 2015 ²⁸	Accelerometer	DEXA for BMI and fat body mass as percentage; waist circumference and skinfold thickness (triceps and biceps)	Socioeconomic status and measurement of serum cotinine
Falconer et al. 2015 ¹⁹	Accelerometer	Height and weight, BMI, waist circumference.	Serum cholesterol, triglycerides, HOMA-IR, glucose, blood pressure.
Petersen et al. 2017 ³³	Accelerometer and heart rate monitor	Height and weight, BMI, waist circumference, visceral and subcutaneous fat by ultrasound system	Lifestyle profile by interview
Curtis et al. 2020 ³⁶	Accelerometer	Self-reported height and weight	Mental subscale, sociodemographic factors
Panades et al. 2019 ³⁴	Triaxial accelerometer	Height and weight, BMI, waist circumference, Dual-energy X-ray absorptiometry (DEXA)	FBG, HbA1c, LDL-C, HDL-C, TG Blood pressure Self-reported socioeconomic status
Oviedo-Caro et al. 2020 ³²	Multi-sensor monitor	Height, weight by bioelectrical impedance analysis, skinfold thickness, BMI, fat mass index	Cardiorespiratory fitness, sociodemographic factors
Jones et al. 2020 ²⁹	Accelerometer	Height, weight by bioelectrical impedance analysis, BMI, fat mass index	Cardiorespiratory fitness, sociodemographic factors
Tan et al. 2020 ³⁰	International Physical Activity Questionnaire Short Form	Height, weight, BMI, z-score BMI	-

PREFIT: fitness test battery including lower and upper body muscular strength, motor and cardiorespiratory fitness; FBG: fasting blood glucose; TGs: triglycerides; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; TC: total cholesterol; BMI: body mass index; DEXA: Dual-energy X-ray absorptiometry; HOMA-IR: Homeostatic Model Assessment-Insulin Resistance; HbA1c: glycated hemoglobin.

the included studies did not present ethnic diversity, which can difficult the generalizability of the data. Similarly, body composition was evaluated by using different methods, which combined with other differences regarding the development of the ISM of each included study did not allow us to perform a meta-analysis. Therefore, our review only analyzed the studies.

It is important to consider that establishing goals based on small changes in lifestyle behavior can be more feasible when compared

to major changes that require not only individual commitment, but also community support. Additionally, identifying the minimum amount of time that can be replaced and induce short and/or long-term health benefits is equally necessary. Therefore, ISM can contribute to address these possible lifestyle changes and, hence, provide a basis for development of several behavior-based interventions. Although we focused on body composition change, ISM can estimate other outcomes, for instance changes in

Table 4: Physical activity and sedentary behavior assessment.

Study	Wear time	SB	LIPA	Moderate Physical Activity	Vigorous Physical Activity	MVPA	Sleep	Magnitude
Leppanen et al. 2016 ²⁴	7 days for 24 hours	< 305	306-817	818-1968	> 1969	> 818	Diary	Vector magnitudes in 10-s epochs
Varela-Mato et al. 2017 ²¹	7 days for 24 hours		< 100	-	-	> 100	< 20 steps/min during 60 min	Step/min
Aggio et al. 2015 ²⁵	7 days during awakening	< 100	-	-	-	> 3000	-	Counts per minute
Pozo-Cruz et al. 2017 ²⁶	7 days during awakening	< 1.5 < 149	1.5-3 150-499	3-6 500-3999	≤ 6 > 4000	-	Self-report	MET Counts per minute
Boyle et al. 2017 ³⁵	7 days during awakening	< 100	100-1951	-	-	> 1952	Self-report	Counts per minute
Leppanen et al. 2017 ¹⁴	7 days for 24 hours	≤ 305	306-817	818-1968	> 1969	> 818	-	Vector magnitudes in 10-s epochs
Collings et al. 2016 ²⁷	6-8 days for 24 hours	< 1.5	1.5-3	3,0-6	> 6	-	-	MET
Collings et al. 2017 ²³	9 days for 24 hours	< 820	820-3907	-	-	> 3908	Parents report	Counts per minute
Dumuid et al. 201 ³¹	7 days for 24 hours	≤ 25	26-573	-	-	≥ 547	0 counts per minute during ≥ 20 min	Counts per 15 seconds
Loprinzi et al. 2015 ²⁸	7 days for 24 hours	< 99	≥ 100-1951	1952-5724	5724-9498	-	-	Counts per minute
Falconer et al. 2015 ¹⁹	7 days for 24 hours	≤ 100	< 3 ≤ 1952	3-5.99	6-8.99	≥ 1952	-	MET Counts per minute
Petersen et al. 2017 ³³	5 days for 24 hours	1-1.5	1.5-3	3-6	> 6	> 3	-	MET
Curtis et al 2020 ³⁶	7 days for 24 hours		> 188	> 403	> 1131	-	Diary	Counts per minute
Panades et al. 2019 ³⁴	7 days for 24 hours	< 1.5	1.5-3	-	-	> 3	Diary and noncount night period	MET
Oviedo-Caro et al. 2020 ³²	9 days for 24 hours	-	-	-	-	-	-	-
Jones et al 2020 ²⁹	8 days for 24 hours	< 483	484-1587	-	-	1590	-	Counts per minute
Tan et al 2020 ³⁰ *	7 days	Sitting, lying but not sleeping	Walking	Slight exhaustion	Extreme exhaustion	-	-	Sum of time spent in the activities

MET: Metabolic Equivalent of Task; MVPA: Moderate-to-vigorous physical activity.
 *Assessed through International Physical Activity Questionnaire - Short Form.

metabolic biomarkers that are relevant in many diseases such as obesity, diabetes, cancer, pulmonary diseases.

Therefore, ISM is a statistical approach applied to physical activity epidemiology, which its use has been rising, especially to replace sedentary behavior by physical activity regardless of intensity. Although the blocks of time vary according to the included studies, replacing even small blocks of time (five minutes) per day of sedentary behavior by MVPA is associated with body composition change. These data obtained by using the ISM can contribute to development

of behavior-based interventions and to guide public policies in order to promote physical activity and prevent sedentary behavior.

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REFERENCES

- Mekary RA, Willett WC, Hu FB, Ding EL. Isotemporal substitution paradigm for physical activity epidemiology and weight change. *Am J Epidemiol*. 2009;170(4):519-27. <http://doi.org/10.1093/aje/kwp163>
- Willett W, Stampfer MJ. Total energy intake: Implications for epidemiologic analyses. *Am J Epidemiol*. 1986;124(1):17-27. <http://doi.org/10.1093/oxfordjournals.aje.a114366>
- Willett WC, Howe GR, Kushi LH. Adjustment for total energy intake in epidemiologic studies. *Am J Clin Nutr*. 1997;65(4 Suppl):1220S-8S. <http://doi.org/10.1093/ajcn/65.4.1220S>
- Dumuid D, Wake M, Clifford S, Burgner D, Carlin JB, Mensah FK, et al. The Association of the Body Composition of Children with 24-Hour Activity Composition. *J Pediatr*. 2019;208:43-9.e9. <http://doi.org/10.1016/j.jpeds.2018.12.030>
- Pedišić Ž, Dumuid D, Olds TS. Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: Definitions, concepts, statistical methods, theoretical framework, and future directions. *Kinesiology*. 2017;49(2):1-17.
- American College of Sports Medicine (ACSM). Guidelines for exercise testing and prescription. 10th edition. Philadelphia: Wolters Kluwer Health, 2018.
- Keane E, Li X, Harrington JM, Fitzgerald AP, Perry IJ, Kearney PM. Physical activity, sedentary behavior and the risk of overweight and obesity in school-aged children. *Pediatr Exerc Sci*. 2017;29(3):408-18. <http://doi.org/10.1123/pes.2016-0234>
- McPhee JS, French DP, Jackson D, Nazroo J, Pendleton N, Degens H. Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology*. 2016;17(3):567-80. <http://doi.org/10.1007/s10522-016-9641-0>
- World Health Organization (WHO). Physical activity. Available from: <https://www.who.int/news-room/fact-sheets/detail/physical-activity>.
- Wu XY, Han LH, Zhang JH, Luo S, Hu JW, Sun K. The influence of physical activity, sedentary behavior on health-related quality of life among the general population of children and adolescents: A systematic review. *PLoS One*. 2017;12(11):e0187668. <http://doi.org/10.1371/journal.pone.0187668>
- Rezende LFM, Rey-López JP, Matsudo VKR, Luiz ODC. Sedentary behavior and health outcomes among older adults: A systematic review. *BMC Public Health*. 2014;14:333. <http://doi.org/10.1186/1471-2458-14-333>
- Mekary RA, Ding EL. Isotemporal Substitution as the Gold Standard Model for Physical Activity Epidemiology: Why It Is the Most Appropriate for Activity Time Research. *Int J Environ Res Public Health*. 2019;16(5):797. <http://doi.org/10.3390/ijerph16050797>
- World Health Organization (WHO). Physical status: the use and interpretation of Anthropometry. Available from: https://www.who.int/childgrowth/publications/physical_status/en/
- Leppänen MH, Henriksson P, Delisle Nyström C, Henriksson H, Ortega FB, Pomeroy J, et al. Longitudinal physical activity, body composition, and physical fitness in preschoolers. *Med Sci Sports Exerc*. 2017;49(10):2078-85. <http://doi.org/10.1249/MSS.0000000000001313>
- Matsudo S, Araujo T, Matsudo V, Andrade D, Andrade E, Oliveira LC, et al. Questionário Internacional de Atividade Física (IPAQ): estudo de validade e reprodutibilidade no Brasil. *Soc Bras Ativ Fis Saude*. 2001;6(2):5-18. <https://doi.org/10.12820/rbafs.v.6n2p5-18>
- Miguel JH, Cadenas-Sanchez C, Ekelund U, Nyström CD, Mora-Gonzalez J, Löf M, et al. Accelerometer data collection and processing criteria to assess physical activity and other outcomes: a systematic review and practical considerations. *Sport Med*. 2017;47(9):1821-45. <https://doi.org/10.1007/s40279-017-0716-0>
- Skender S, Ose J, Chang-Claude J, Paskow M, Brühmann B, Siegel EM, Steindorf K, et al. Accelerometry and physical activity questionnaires - a systematic review. *BMC Public Health*. 2016;16:515. <https://doi.org/10.1186/s12889-016-3172-0>
- Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group. Principais itens para relatar Revisões sistemáticas e Meta-análises: a recomendação PRISMA. *Epidemiol Serv Saude*. 2015;24(2):335-42. <http://dx.doi.org/10.5123/S1679-49742015000200017>
- Falconer CL, Page AS, Andrews RC, Cooper AR. The potential impact of displacing sedentary time in adults with type 2 Diabetes. *Med Sci Sports Exerc*. 2015;47(10):2070-5. <https://doi.org/10.1249/MSS.0000000000000651>
- Ferreira RW, Rombaldi AJ, Ricardo LIC, Hallal PC, Azevedo MR. Prevalence of sedentary behavior and its correlates among primary and secondary school students. *Rev Paul Pediatr*. 2016;34(1):56-63. <https://doi.org/10.1016/j.rppede.2015.09.002>
- Varela-Mato V, O'Shea O, King JA, Yates T, Stensel DJ, Biddle SJ, et al. Cross-sectional surveillance study to phenotype lorry drivers' sedentary behaviours, physical activity and cardio-metabolic health. *BMJ Open*. 2017;7(6):e013162. <http://doi.org/10.1136/bmjopen-2016-013162>
- Danquah IH, Pedersen ESL, Petersen CB, Aadahl M, Holtermann A, Tolstrup JS. Estimated impact of replacing sitting with standing at work on indicators of body composition: Cross-sectional and longitudinal findings using isotemporal substitution analysis on data from the Take a Stand! study. *PLoS One*. 2018;13(6):e0198000. <http://doi.org/10.1371/journal.pone.0198000>
- Collings PJ, Brage S, Bingham DD, Costa S, West J, McEachan RRC, et al. Physical Activity, Sedentary Time, and Fatness in a Biethnic Sample of Young Children. *Med Sci Sports Exerc*. 2017;49(5):930-8. <http://doi.org/10.1249/MSS.0000000000001180>
- Leppänen MH, Nyström CD, Henriksson P, Pomeroy J, Ruiz JR, Ortega FB, et al. Physical activity intensity, sedentary behavior, body composition and physical fitness in 4-year-old children: results from the ministop trial. *Int J Obes*. 2016;40(7):1126-33. <http://doi.org/10.1038/ijo.2016.54>
- Aggio D, Smith L, Hamer M. Effects of reallocating time in different activity intensities on health and fitness: A cross sectional study. *Int J Behav Nutr Phys Act*. 2015;12:83. <http://doi.org/10.1186/s12966-015-0249-6>
- Del Pozo-Cruz B, Gant N, Del Pozo-Cruz J, Maddison R. Relationships between sleep duration, physical activity and body mass index in young New Zealanders: An isotemporal substitution analysis. *PLoS One*. 2017;12(9):e0184472. <http://doi.org/10.1371/journal.pone.0184472>
- Collings PJ, Westgate K, Väistö J, Wijndaele K, Atkin AJ, Haapala EA, et al. Cross-Sectional Associations of Objectively-Measured Physical Activity and Sedentary Time with Body Composition and Cardiorespiratory Fitness in Mid-Childhood: The PANIC Study. *Sport Med*. 2017;47(4):769-80. <http://doi.org/10.1007/s40279-016-0606-x>

28. Loprinzi PD, Cardinal BJ, Lee H, Tudor-Locke C. Markers of adiposity among children and adolescents: implications of the isotemporal substitution paradigm with sedentary behavior and physical activity patterns. *J Diabetes Metab Disord.* 2015;14:46. <http://doi.org/10.1186/s40200-015-0175-9>
29. Jones MA, Skidmore PM, Stoner L, Harrex H, Saeedi P, Black K, et al. Associations of accelerometer-measured sedentary time, sedentary bouts, and physical activity with adiposity and fitness in children. *J Sports Sci.* 2020;38(1):114-20. <http://doi.org/10.1080/02640414.2019.1685842>
30. Tan K, Cai L, Lai L, Gui Z, Zeng X, Lv Y, et al. Association of reallocating time in different intensities of physical activity with weight status changes among normal-weight chinese children: A national prospective study. *Int J Environ Res Public Health.* 2020;17(16):5761. <http://doi.org/10.3390/ijerph17165761>
31. Dumuid D, Stanford TE, PEDI Z, Maher C, Lewis LK, Martín-Fernández JA, et al. Adiposity and the isotemporal substitution of physical activity, sedentary time and sleep among school-aged children: a compositional data analysis approach. *BMC Public Health.* 2018;18:311. <https://doi.org/10.1186/s12889-018-5207-1>
32. Oviedo-Caro MA, Bueno-Antequera J, Munguía-Izquierdo D. Associations of 24-hours activity composition with adiposity and cardiorespiratory fitness: the PregnActive project. *Scand J Med Sci Sport.* 2020;30(2):295-302. <https://doi.org/10.1111/sms.13566>
33. Dahl-Petersen IK, Brage S, Bjerregaard P, Tolstrup J, Jorgensen ME. Physical activity and abdominal fat distribution in Greenland. *Med Sci Sports Exerc.* 2017;49(10):2064-70. <https://doi.org/10.1249/MSS.0000000000001337>
34. Galmes-Panades AM, Varela-Mato V, Konieczna J, Wärnberg J, Martínez-González MA, Salas-Salvadó J, et al. Isotemporal substitution of inactive time with physical activity and time in bed: Cross-sectional associations with cardiometabolic health in the PREDIMED-Plus study. *Int J Behav Nutr Phys Act.* 2019;16:137. <https://doi.org/10.1186/s12966-019-0892-4>
35. Boyle T, Vallance JK, Buman MP, Lynch BM. Reallocating time to sleep, sedentary time, or physical activity: Associations with waist circumference and body mass index in breast cancer survivors. *Cancer Epidemiol Biomarkers Prev.* 2017;26(2):254-60. <http://doi.org/10.1158/1055-9965.EPI-16-0545>
36. Curtis RG, Dumuid D, Olds T, Plotnikoff R, Vandelanotte C, Ryan J, et al. The association between time-use behaviors and physical and mental well-being in adults: a compositional isotemporal substitution analysis. *J Phys Act Heal.* 2020;17(2):197-203. <https://doi.org/10.1123/jpah.2018-0687>
37. 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://doi.org/10.1097/00005768-199805000-00021>
38. Freedson P, Pober D, Janz KF. Calibration of accelerometer output for children. *Med Sci Sports Exerc.* 2005;37(11 Suppl):S523-30. <http://doi.org/10.1249/01.mss.0000185658.28284.ba>
39. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. *J Sports Sci.* 2008;26(1):1557-65. <https://doi.org/10.1080/02640410802334196>
40. Booth FW, Roberts CK, Thyfault JP, Rueggsegger GN, Toedebusch RG. Role of inactivity in chronic diseases: Evolutionary insight and pathophysiological mechanisms. *Physiol Rev.* 2017;97(4):1351-1402. <https://doi.org/10.1152/physrev.00019.2016>
41. Trost SG, Loprinzi PD, Moore R, Pfeiffer KA. Comparison of accelerometer cut points for predicting activity intensity in youth. *Med Sci Sports Exerc.* 2011;43(7):1360-8. <https://doi.org/10.1249/MSS.0b013e318206476e>
42. Strath SJ, Bassett DR, Swartz AM. Comparison of MTI accelerometer cut-points for predicting time spent in physical activity. *Int J Sports Med.* 2003;24(4):298-303. <https://doi.org/10.1055/s-2003-39504>
43. Bianchim MS, McNarry MA, Larun L, Mackintosh KA, ActiveYouth SRC group, Applied Sports Science Technology, et al. Calibration and validation of accelerometry to measure physical activity in adult clinical groups: a systematic review. *Prev Med Rep.* 2019;16:101001. <https://doi.org/10.1016/j.pmedr.2019.101001>
44. Colley RC, Tremblay MS. Moderate and vigorous physical activity intensity cut-points for the Actical accelerometer. *J Sports Sci.* 2011;29(8):783-9. <https://doi.org/10.1080/02640414.2011.557744>
45. World Health Organization (WHO). Obesity and overweight. Available from: <https://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight>.
46. Nittari G, Scuri S, Petrelli F, Pirillo I, Di Luca NM, Grappasonni I. Fighting obesity in children from European World Health Organization member states. Epidemiological data, medical-social aspects, and prevention programs. *Clin Ter.* 2019;170(3):e223-30. <https://doi.org/10.7417/CT.2019.2137>
47. Spinelli A, Buoncristiano M, Kovacs VA, Yngve A, Spiroski I, Obreja G, et al. Prevalence of severe obesity among primary school children in 21 European countries. *Obes Facts.* 2019;12(2):244-58. <https://doi.org/10.1159/000500436>
48. Rivera JA, Cossío TG, Pedraza LS, Aburto TC, Sánchez TG, Martorell R. Childhood and adolescent overweight and obesity in Latin America: A systematic review. *Lancet Diabetes Endocrinol.* 2014;2(4):321-32. [https://doi.org/10.1016/S2213-8587\(13\)70173-6](https://doi.org/10.1016/S2213-8587(13)70173-6)
49. Marques A, Peralta M, Naia A, Loureiro N, Matos MG. Prevalence of adult overweight and obesity in 20 European countries, 2014. *Eur J Public Health.* 2018;28(2):295-300. <https://doi.org/10.1093/eurpub/ckx143>
50. Hales CM, Fryar CD, Carroll MD, Freedman DS, Ogden CL. Trends in obesity and severe obesity prevalence in US youth and adults by sex and age, 2007-2008 to 2015-2016. *JAMA.* 2018;319(16):1723-5. <https://doi.org/10.1001/jama.2018.3060>
51. Kalish VB. Obesity in older adults. *Prim Care Clin Office Pract.* 2016;43:137-44. <http://dx.doi.org/10.1016/j.pop.2015.10.002>
52. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Guia Alimentar para a População Brasileira. 2 ed. Brasília: Ministério da Saúde. 2014.
53. American Institutes for Reserch (AIR). Federal Interagency Forum on Aging-Related Statistics. Available from: <https://www.air.org/project/federal-interagency-forum-aging-related-statistics>
54. Zink J, Belcher BR, Imm K, Leventhal AM. The relationship between screen-based sedentary behaviors and symptoms of depression and anxiety in youth: a systematic review of moderating variables. *BMC Public Health.* 2020;20:472. <https://doi.org/10.1186/s12889-020-08572-1>
55. Shaphe MA, Chahal A. Relation of physical activity with the depression: a short review. *J Lifestyle Med.* 2020;10(1):1-6. <https://doi.org/10.15280/jlm.2020.10.1.1>
56. Grgic J, Dumuid D, Bengoechea EG, Shrestha N, Bauman A, Olds T, et al. Health outcomes associated with reallocations of time between sleep, sedentary behaviour, and physical activity: A systematic scoping review of isotemporal substitution studies. *Int J Behav Nutr Phys Act.* 2018;15(1):69. <http://doi.org/10.1186/s12966-018-0691-3>