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ORIGINAL RESEARCH

Questionnaire-Based Prevalence of Physical Activity Level on Adults According to Different International Guidelines: Impact on Surveillance and Policies

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Background: The World Health Organization recommends 150 minutes of moderate to vigorous physical activity (PA) throughout the week. However, the weekly frequency of PA and how to combine moderate and vigorous PA to define who reaches the recommended PA are controversial. PA level might be highly different based on the recommendation and/or the criteria employed. **Methods**: Demographic data and PA level evaluated by International Physical Activity Questionnaire from 3 random and representative samples from 1 state, 1 city, and 1 local organization in Brazil were analyzed (n = 2961). Nine criteria from different recommendations were used to define PA level. Prevalence estimates and 95% confidence intervals of sufficient PA were calculated for each criterion and compared with the referent (World Health Organization guideline). Total agreement, sensitivity, and specificity were also calculated with 95% confidence interval. **Results**: When a weekly frequency of PA was required, the prevalence of sufficient PA decreased by 11% ($P < .05$). For all criteria, doubling the vigorous PA minutes was similar to simply adding them to moderate PA. These findings are consistent regardless of sex, age, and educational level. **Conclusion**: Prevalence estimates and agreement between different PA recommendations were significantly affected when a minimum frequency was required but did not change when vigorous PA minutes were doubled.

Keywords: guidelines and recommendations, epidemiology, health behavior, physical activity assessment

Currently, the scientific evidences of a wide range of health benefits associated with regular physical activity (PA) are unequivocal.[1–3] However, about one third of women and 1 in 4 men worldwide are not sufficiently active.[4] Thereafter, insufficient PA stands out as one the leading risk factor for mortality, killing more than 5 million people per year worldwide.[2] Active people show a huge variety of health benefits, such as a lower overall and cardiovascular mortality, a lower risk of high blood pressure, diabetes, breast and colon cancer, depression, and obesity, as compared with the less active ones.[3,5–7] Defining exactly how much weekly PA is sufficient to enjoy most of the PA health-related benefits is a challenge for epidemiologists, policymakers, and PA promotion leaders. Individuals have been classified as active or insufficient active if they are above or below a chosen criterion of weekly PA accumulation.[8–10]

Measuring PA is another challenge for epidemiologists. Self-report (questionnaire) is often used, especially in low- and middle-income countries in which large scale use of accelerometers and pedometers are often not feasible.[4] Also, when considering PA surveillance purposes, data collected through accelerometers are mostly only available for high-income countries, and results are often not comparable because of variations in data collection methods, data processing, and scoring.[4,11] Also, worldwide data from questionnaires are available from 168 countries.[4]

In Brazil, the International Physical Activity Questionnaire (IPAQ) is the most used questionnaire,[12] especially the short form, which has been translated and validated for more than 17 years.[13] However, the scoring protocol proposed by the IPAQ committee is based on a PA recommendation that requires a minimal weekly frequency of PA to classify someone as active[14–16] PA recommendations have evolved alongside PA health-benefit research, and thus, recent research sometimes uses guidelines other than the one proposed by the IPAQ committee[17] to classify subjects as active or insufficiently active.

Reference standards are usually defined either by cross-sectional or by longitudinal studies that compare the proportions or the risk-related health outcomes between active and insufficient active groups.[18,19] Noteworthy, however, the composition of the active and the insufficient active groups are crucial, and different criteria may result in different or biased conclusions.[20]

The IPAQ classifies as active someone, who has 3 or more days of vigorous-intensity activity of at least 20 minutes per day, 5 or more days of moderate-intensity activity and/or walking of at least 30 minutes per day or 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum total PA of at least 600 metabolic equivalent (MET)-minutes per week.[16] This is mainly based in the 1995, the American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention recommendation[14]

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After more than 20 years, ACSM,[8] the US Government,[9] the British Association of Sport and Exercise Sciences (BRIT),[21] and the Australian Government[22] have also published their own guidelines, each one with its nuances. On a global scale, one of the most influential documents was published by the World Health Organization (WHO) in 2010.[10] All of them recommend at least 150 minutes of moderate to vigorous physical activity (MVPA) per week.

Albeit this agreement, there are many differences as regard to PA intensity, frequency, and how to compute any combination of MVPA. Regarding PA frequency, differences are especially evident in the newer recommendations due to recent evidence that the weekend warrior behavior is also associated with health benefits.[23,24]

Major differences between guidelines are (1) the quantity of vigorous PA (VPA) per week (60 vs 75 min), (2) the frequency of MVPA per week (5 d/wk vs none), and (3) how to combine moderate and vigorous physical activities (simple addition of MVPA minutes or an addition that computes vigorous minutes in double). As to the last criterion, the WHO recommendation states that one could be active with an "equivalent combination of moderate- and vigorous-intensity activity," not being clear on how the equivalent activities should be accounted for.[10]

Another way to combine MVPA is by considering their energy expenditure, that is, by computing the total MET-minutes per week. Again, some inconsistencies appear. The ACSM recommends at least 450 MET-minutes per week,[8] and the IPAQ Committee proposes a minimum of 600 MET-minutes per week. Of note, using the IPAQ one could be classified as active if reporting 5 days per week of walking for 30 minutes per day, and this pattern would correspond only to 495 MET-minutes per week.[16]

Although some differences on the prevalence estimates of PA level are expected depending on the PA classification criterion used, its magnitude and specificity as for the PA intensity, frequency, or combination possibilities have not been fully addressed. To the best of our knowledge a small number of studies[25–28] have pointed out the impact of different recommendations on PA prevalence estimates, normally showing that the requirement of a minimal frequency decreased the number of people classified as active. However, their analyses were sometimes restricted to PA domains or criterion[27–29] or specific populations such as adolescents,[25] college students,[26] or middle-aged men.[30]

Thus, aiming a more comprehensive analysis, we compared the impact of 9 different PA recommendations on the prevalence estimates of PA level, evaluated in all PA domains, among 3 random and representative samples from a state, a city, and a local organization in Brazil.

Methods

We conducted a cross-sectional study among 2961 men and women (18–70 y) recruited from 3 different populations. To perform a broader analysis and to minimize the influences of the population characteristics, we randomly selected volunteers from 3 different adult populations, each one of them possessing their own particularities. All samples were representative of their respective populations. One group is a representative sample from São Paulo state, the most populous Brazilian state (n = 2222). The second one is a representative sample from Belo Horizonte, which is one of the biggest Brazilian cities, located in a different state (n = 356). Finally, we used a local and restricted sample from Brasilia, Brazil's capital, composed by civil servants of a Brazilian public agency (n = 383).

Sample sizes were calculated with a level of significance of 95% and acceptable error of 5% for the Brasilia and Belo Horizonte samples and of 2% for the São Paulo one. Due to different geographical and population size, the sampling process for São Paulo state was done by 7 different geographical regions (clusters) defined by the number of inhabitants and some characteristics such as metropolitan versus coast areas. Of note, the Brasilia sample was based on the conservative estimated prevalence of inactivity of 50%, resulting on a proportionally bigger sample size for that population. In the Brasilia sample, we ended up with more volunteers than the minimum (±15%), and for the Belo Horizonte and São Paulo samples, we had valid data for ±92.5% of the calculated sample sizes due to incomplete or inconsistent data for the present analysis. The refusal rates among all clusters, in all samples, varied from 4.6% to 12.1%. Of note, those rates were small because nonresponders were automatically replaced by another randomly selected volunteers who met the same predefined sample characteristics, such as gender or geographical region.

The use of sample with heterogeneous characteristics is interesting as participants with lower PA levels will probably suffer a larger impact from using different criteria, and variation in VPA will also be higher, to better examine the effect of not doubling PA minutes. Also, considering that the sociodemographic characteristics, such as socioeconomic status, gender, and schooling, are associated with questionnaire-based PA level, different samples with broader characteristics would add value for our analysis proposal.

Physical activity level was assessed by the IPAQ Portuguese short version.[13] In the São Paulo and the Belo Horizonte samples, the IPAQ was administered by interview. In the Brasilia sample, we used the self-administered method preceded by a general explanation and followed by an interview to solve problems such as missing or incorrect values. Raw data was stored in a Microsoft Excel ((Microsoft, Redmond, WA) spreadsheet. To evaluate the effect of using different guidelines with IPAQ to estimate the prevalence of sufficient PA level, 9 criteria were used to classify raw data, as follows:

1. WHO2VPA: 150 minutes of MVPA per week or 75 minutes of VPA, irrespective of the weekly frequency (days/week), doubling the minutes of vigorous activities for MVPA combinations (2VPA);
2. WHO: similar to WHO2VPA without doubling the minutes of VPA for MVPA combinations;
3. IPAQ2VPA: 150 minutes of MVPA in at least 5 days per week or 60 minutes of VPA in at least 3 days per week, doubling the minutes of VPA for MVPA combinations;
4. IPAQ: similar to IPAQ2VPA without doubling the minutes of VPA for MVPA combinations;
5. BRIT2VPA: 150 minutes of MVPA or 75 minutes of VPA in at least 5 days per week, doubling the minutes of VPA for MVPA combinations;
6. BRIT: similar to BRIT2VPA without doubling the minutes of VPA for MVPA combinations;
7. 600METS: 600 METs-minutes per week, irrespective of the number of days per week;
8. 495METS: 495 METs-minutes per week, irrespective of the number of days per week; and
9. 450METS: 450 METs-minutes per week, irrespective of the number of days per week.

Criteria number 1, 3, and 5 were derived and followed literally from the official recommendations postulated by the WHO, the IPAQ Committee, and the BRIT,[10,16,21] respectively. Recommendation

number 1 was used as the reference, as it is the WHO's recommendation applying the interpretation of any "equivalent combination of moderate- and vigorous-intensity activity" as the necessity to double VPA by analogy of the 150 minutes of moderate PA and the 75 minutes of VPA.[10] To evaluate the impact of the different ways to account for VPA minutes, instead of doubling the VPA minutes, they were simply added—criteria number 2, 4, and 6.

Some recommendations also consider a minimum weekly energy expenditure. The IPAQ committee states that to be active, one could perform any combination of walking, MVPA achieving a minimum total of at least 600 MET-minutes per week[16] (criteria number 7). In spite of this recommendation, walking 150 minutes—a 3.3 MET-minute activity in the IPAQ protocol[16]—would mean a 495 MET-minutes per week (criteria number 8). ACSM[8] recommends performing at least 450 MET-minutes per week, that is, 150 minutes of MPA (criteria number 9).

Statistical Analysis

Prevalence estimates and 95% confidence interval (CI) were calculated for each of the 9 standards points used. Comparisons between the 9 measures were determined using WHO2VPA-defined physical activity level (PAL) as the reference measure. Agreement analysis was done by the following epidemiological indexes: (1) total agreement (TA), or accuracy, as the sum of the percentage of true positive (TP) and true negative (TN) values (TA = TP + TN); (2) sensitivity (sensitivity = [TP/(TP + FN)] × 100%), where FN is false negative; and (3) specificity (specificity = [TN/(TN + FP)] × 100), where FP is false positive. To evaluate the impact of sociodemographic factors in the criterion points, subanalyses were also performed by gender, educational level (seventh grade or less; from eighth grade to uncompleted high school; from completed high school to uncompleted higher education and undergraduate/graduated volunteers), and age (18–39, 40–59, and 60–70 y).

Results

Mean age (SD) of the participants was 40.3 (14.1) years. In the total sample, 1504 were women (50.8%), 473 (16.0%) studied only until the seventh grade, 407 (13.8%) had educational level between eighth grade and an uncompleted high school, 1218 (41.2%) had uncompleted college degree, and 860 (29.0%) graduated from college or above. The sample from São Paulo aged 40.0 (14.6) years and 50.1% (95% CI, 48.1%–52.2%) were women. The sample from Belo Horizonte aged 39.2 (14.6) years and was composed by 53.1% of women (95% CI, 47.9%–58.2%). The

sample from Brasilia aged 40.0 (9.9) years and had 52.2% of women (95% CI, 47.2%–57.2%). Despite the similarity of age between groups, there was an absence of younger volunteers (from 18 to 23 y) in the Brasília sample. There was no statistical difference on the gender proportion among the samples. As regard to the educational level, the Brasilia sample was different from the others with 82.2% of volunteers with a college degree.

Due to the specificities between the samples, results of prevalence estimates and their differences are shown both as 3 independent samples (Tables 1–3) and as 1 big sample (Table 4). Of note, the 3 samples separately or together presented the same qualitatively phenomenon, that is, lower prevalence estimates of sufficient PA on the 4 recommendations that includes a minimum frequency of days per week (IPAQ2VPA, IPAQ, BRIT2VPA, and BRIT—significant for São Paulo and Brasilia samples, whereas the Belo Horizonte sample showed a small overlap between 95% CI), in comparison with the other 5, which were similar between them (WHO2VPA, WHO, 600METs, 495METs, and 450METS). Considering this phenomenon, the results of TA, sensitivity, and specificity are presented considering only the total sample (Table 4). We also observed a very consistent and similar pattern on data for each category of gender, age, and educational level. Results of each category showed a very small variation as compared with the total sample, usually <1% in the 95% CI limits. The only exception was for those with lower education level (seventh grade or less) where the significance of the differences on the prevalence estimates of sufficient PA were borderline for IPAQ2VPA, IPAQ, and BRIT2VPA (95% CI slightly overlapping as compared with WHO2VPA) and significant for BRIT. Detailed results by categories of gender, age, and educational level are shown as in Supplementary Materials (see Supplementary Tables S1–S9 [available online]).

Figure 1 shows the prevalence of active individuals using the 9 different standard points in the 3 representative samples separately, whereas Figure 2 shows the results for the whole group.

When considering all comparisons of the prevalence estimates of sufficient PA (expect from the lower educational level group in which the differences were borderline), the mean difference between the 4 recommendations that controlled frequency and those that did not was −11.0% (−9.7/−13.6%). Also, considering the frequency criterion results on a mean reduction on TA of −9.3% (−7.8/11.9%), and on sensitivity of −12.9% (−11.0/−15.5%) with no effect on specificity, apart from the 495 and 450 METs-minutes per week cases in which specificity drops 3.6% and 13.5%, respectively.

Of note, on the reference recommendation, which does not consider the days per week criterion, there were only few volunteers those did not reach the minimum threshold to be considered

Table 1 **Prevalence of Physically Active Individuals in a Random and Representative Sample of a Brazilian State (São Paulo) According to Each PA Recommendation and the Differences Between Recommendations Considering WHO2VPA as Reference (n = 2222)**

	WHO2VPA	WHO	IPAQ2VPA	IPAQ	BRIT2VPA	BRIT	600METS	495METS	450METS
Physically active, %	82.2 (80.5–83.7)	81.6 (80.0–83.2)	72.3* (70.4–74.1)	71.9* (70.0–73.7)	71.7* (69.8–73.5)	71.2* (69.3–73.1)	80.4 (78.7–82.0)	82.9 (81.3–84.5)	84.7 (83.2–86.2)
Δ Absolute		−0.5	−9.9	−10.3	−10.5	−10.9	−1.8	0.8	2.6
Δ Relative		−0.7	−12.0	−12.5	−12.8	−13.3	−2.2	0.9	3.1

Abbreviations: 2VPA, vigorous activities minutes doubled for MVPA combinations; BRIT, British Association of Sport and Exercise Sciences guideline; IPAQ, International Physical Activity Questionnaire guideline; METS, metabolic equivalent; MVPA, moderate to vigorous physical activity; WHO, World Health Organization guideline.
*Statistically different.

Table 2 Prevalence of Physically Active Individuals in a Random and Representative Sample of a Brazilian City (Belo Horizonte) According to Each PA Recommendation and the Differences Between Recommendations Considering WHO2VPA as Reference (n = 356)

	WHO2VPA	WHO	IPAQ2VPA	IPAQ	BRIT2VPA	BRIT	600METS	495METS	450METS
Physically active, %	76.7 (72.0–80.8)	76.1 (71.4–80.3)	69.7 (64.7–74.2)	69.4 (64.4–73.9)	69.1 (64.4–73.7)	68.3 (63.3–72.9)	75.0 (70.3–79.2)	77.5 (72.9–81.6)	80.9 (76.5–84.6)
Δ Absolute		−0.6	−7.0	−7.3	−7.6	−8.4	−1.7	0.8	4.2
Δ Relative		−0.7	−9.2	−9.5	−9.9	−11.0	−2.2	1.1	5.5

Abbreviations: 2VPA, vigorous activities minutes doubled for MVPA combinations; BRIT, British Association of Sport and Exercise Sciences guideline; IPAQ, International Physical Activity Questionnaire guideline; METS, metabolic equivalent; MVPA, moderate to vigorous physical activity; WHO, World Health Organization guideline.

Table 3 Prevalence of Physically Active Individuals in a Random and Representative Sample of Civil Servants From a Brasilia Public Agency According to Each PA Recommendation and the Differences Between Recommendations Considering WHO2VPA as Reference (n = 383)

	WHO2VPA	WHO	IPAQ2VPA	IPAQ	BRIT2VPA	BRIT	600METS	495METS	450METS
Physically active, %	66.6 (61.7–71.1)	65.5 (60.6–70.1)	54.3* (49.3–59.2)	54.3* (49.3–59.2)	52.2* (47.2–57.2)	52.2* (47.2–57.2)	64.8 (59.8–69.4)	67.1 (62.2–71.6)	69.2 (64.4–73.6)
Δ Absolute		−1.0	−12.3	−12.3	−14.4	−14.4	−1.8	0.5	2.6
Δ Relative		−1.6	−18.4	−18.4	−21.6	−21.6	−2.7	0.8	3.9

Abbreviations: 2VPA, vigorous activities minutes doubled for MVPA combinations; BRIT, British Association of Sport and Exercise Sciences guideline; IPAQ, International Physical Activity Questionnaire guideline; METS, metabolic equivalent; MVPA, moderate to vigorous physical activity; WHO, World Health Organization guideline.
*Statistically different.

Table 4 Prevalence of Physically Active Individuals According to Each PA Recommendation, Agreement, Sensibility, Specificity, and Difference Between Recommendations Considering WHO2VPA as Reference (Total Sample; N = 2961)

	WHO2VPA	WHO	IPAQ2VPA	IPAQ	BRIT2VPA	BRIT	600METS	495METS	450METS
Physically active, %	79.5 (78.0–80.9)	78.9 (77.4–80.3)	69.6* (68.0–71.3)	69.3* (67.6–71.0)	68.9* (67.2–70.5)	68.4* (66.7–70.1)	77.7 (76.2–79.2)	80.2 (78.8–81.6)	82.3 (80.9–83.6)
Δ Absolute		−0.6	−9.9	−10.2	−10.6	−11.1	−1.8	0.7	2.8
Δ Relative		−0.8	−12.4	−12.8	−13.4	−13.9	−2.3	0.9	3.5
Total agreement		99.4 (99.0–99.6)	90.1 (89.0–91.2)	89.8 (88.7–90.9)	89.4 (88.2–90.4)	88.9 (87.7–90.0)	98.2 (97.7–98.6)	99.3 (98.9–99.5)	97.2 (97.8–96.6)
Sensitivity		99.2 (98.8–99.5)	87.6 (86.2–88.9)	87.2 (85.8–88.5)	86.6 (85.2–87.9)	86.1 (84.6–87.8)	97.7 (97.1–98.3)	100.0 (99.8–100.0)	100.0 (99.8–100.0)
Specificity		100.0 (99.4–100.0)	100.0 (99.4–100.0)	100.0 (99.4–100.0)	100.0 (99.4–100.0)	100.0 (99.4–100.0)	100.0 (99.4–100.0)	96.4 (94.6–97.6)	86.5 (83.5–89.0)

Abbreviations: 2VPA, vigorous activities minutes doubled for MVPA combinations; BRIT, British Association of Sport and Exercise Sciences guideline; IPAQ, International Physical Activity Questionnaire guideline; METS, metabolic equivalent; MVPA, moderate to vigorous physical activity; WHO, World Health Organization guideline.
*Statistically different.

active. Among them, 32 volunteers (1.1%) did not reach the threshold because of 15 minutes or less of MVPA. While examining only VPA, 80 individuals (2.7%) did not reach the threshold because of less than 15 minutes. Also, VPA was not a major source of PA in our sample. Almost two third of the sample (1878 individuals) did not perform any 10-minute bout of VPA. Considering those who did not meet the IPAQ criterion (ie, duration + frequency) to be active, we observed that 111 individuals (3.7%) accumulated ≥150 minutes MVPA per week but only in 4 days per week and 100 individuals (3.4%) accumulated the minimum amount of PA but only in 3 days per week. Regarding only the VPA, 28 individuals (0.9%) performed at least 60 minutes but only in 2 days per week.

Discussion

In this study, among 2961 men and women from 3 representative Brazilian samples, we observed lower prevalence estimates of PAL
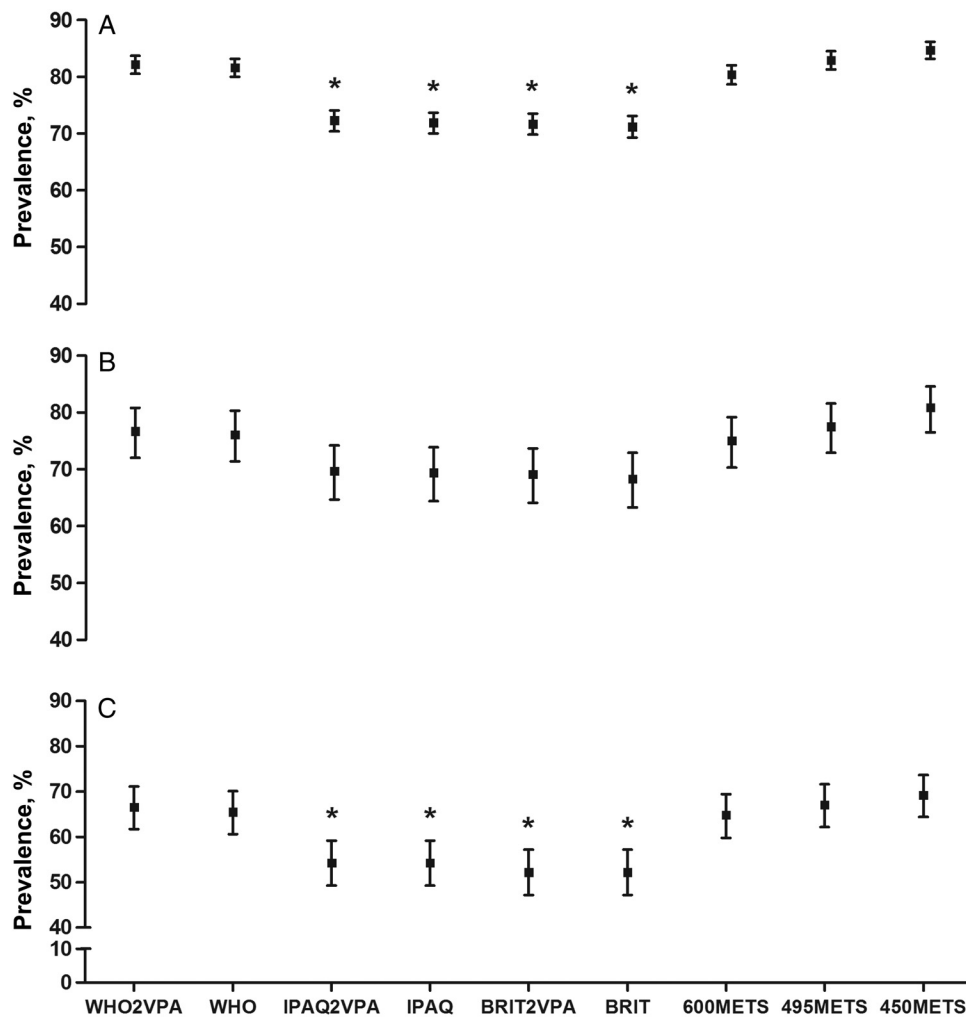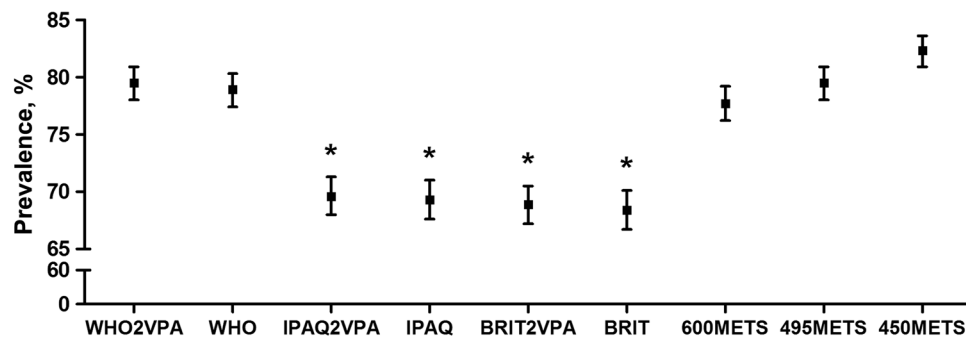
Figure 1 — Prevalence (mean and 95% confidence interval) of physically active individuals according to 9 different cut-off points of PAL based on international recommendations in a random and representative sample of (A) a Brazilian state (n = 2222), (B) a Brazilian city (n = 356), and (C) a sample of civil servants from a Brasilia public agency (n = 383). 2VPA indicates vigorous activities minutes doubled for MVPA combinations; BRIT, British Association of Sport and Exercise Sciences guideline; IPAQ, International Physical Activity Questionnaire guideline; METS, metabolic equivalent; MVPA, moderate to vigorous physical activity; PAL, physical activity level; WHO, World Health Organization guideline. *Statistically different compared to WHO2VPA ($P < .05$).

Figure 2 — Prevalence (mean and 95% confidence interval) of physically active individuals according to 9 different cut-off points of PAL based on international recommendations in a Brazilian sample representative of a state, a city, and a local organization (n = 2961). 2VPA indicates vigorous activities minutes doubled for MVPA combinations; BRIT, British Association of Sport and Exercise Sciences guideline; IPAQ, International Physical Activity Questionnaire guideline; METS, metabolic equivalent; MVPA, moderate to vigorous physical activity; PAL, physical activity level; WHO, World Health Organization guideline. *Statistically different compared to WHO2VPA ($P < .05$).

when the recommendations include a minimum weekly frequency of PA practice (3 or 5 d/wk). The magnitude of the difference was about −11% of active volunteers when the weekly frequency is required. Also, the use of a minimum weekly frequency resulted on a mean reduction of −9.3% of the TA and −12.9% of the sensitivity, with no impact on the specificity. On the other hand, the recommendations that define a lower total amount of PA per week (450 and 495 METs-min/wk) showed similar sensitivity but lower specificity. Altogether, the recommendations/standards that consider a weekly frequency showed lower capacity for identifying sufficient PAL when it was present (TP), and the more complacent threshold (450 METs-min/wk-2007 ACSM recommendation) was less likely to exclude the insufficient PAL when it was present. Of note, those differences on prevalence estimates, TA, sensitivity, and specificity were independent of gender, age, and educational level. Another main finding was the lack of significant difference on the prevalence estimates of sufficient PAL and in the epidemiological indices when vigorous activities were counted in double or not.

Regarding PA surveillance, the use of guidelines in which there is a frequency requirement result in a significantly lower prevalence of physically active individuals, with a difference lower than previously reported in studies using accelerometers that ranged from 20.4% to 62.5%.[26,28,30] Thus, whenever comparing IPAQ prevalence data, attention should be payed to which guidelines were used, considering that if it requires a minimum weekly frequency, the prevalence estimates will probably be significantly smaller as compared with one that does not have such requirements. In those cases, data adjustments might be needed.[4] Also, adding VPA minutes or doubling them did not significantly affect prevalence in accelerometry data, and National Health and Nutrition Examination Survey self-report questionnaire.[31]

The current WHO recommendation is easier to reach because it does not limit how many sessions per week must be done and only requires the accumulation of a certain amount of PA.[10] This approach may increase adherence to PA; hence, it is easier to fulfill the minimum requirements. However, lower frequency do not necessarily represent higher adherence[32] and may increase the risk for the "weekend warrior behavior." Although the evidences of important health benefits associated with small frequencies of PA (1 or 2 d/wk),[24] this kind of behavior might be a source of concern once vigorous physical exertion can trigger the onset of acute myocardial infarction, mainly among sedentary persons.[33]

As in any public health statement, the decision about including or not a minimum threshold stands on a risk-benefit evaluation. In that scenario, new recommendations that tend to consider only the total amount of PA, irrespectively to its frequency,[6] would probably improve safety if they include an alert as to the risk of an incidental session of VPA for those whom are not physically prepared. In parallel, they should also highlight the safety and benefits of the low to moderate intensities.[34]

Of note, our data show that only about one third of our volunteers reported at least one 10-minute bout of VPA. Among the insufficient active participants, by WHO2VPA criterion, only 22 participants (3.6%) reported at least 1 bout of VPA. So, it suggests that most part of the insufficient active volunteers did not rely on VPA to be active. Another indirect evidence of this phenomenon is that the prevalence estimates of sufficient PA did not change significantly when VPA where counted in double. Considering that those data were collected from representative state, municipal, and local populations, it looks like the common concern about the risk of incidental VPA among the less active individuals is probably low, at least in terms of its prevalence. However, public health recommendations must consider not only the proportion of the phenomenon, but also its magnitude. Thereafter, the inclusion of an alert regarding the huge increase in relative risk for cardiovascular acute events associated with incidental VPA, mainly among insufficient active people, should be highly recommended.[33,35]

Future studies are needed to clarify the impacts of PA frequency on behavior change, apart from its effects on reducing negative health outcomes. In other words, new studies should evaluate if the accumulation of 150 minutes of MVPA on a "weekend warrior fashion" is also effective to promote behavioral change toward a more active and healthier lifestyle. Another way to address the requirement for a minimum weekly frequency is to evaluate if low frequencies (1 or 2 d/wk) are better than nothing. In this scenario, there are important studies that support the recommendations that consider only the total amount of PA or a minimum energy expenditure threshold.[23,24,36,37] Also, further researches aiming to identify the effect of the weekly frequency of PA on specific health outcomes (eg, cardiovascular, metabolic, or mental health) are highly desired once the health effect of different number of PA session per week might be outcome specific.

Beside our strong methodological approach and analysis, some limitations must be considered. All comparisons were made based only on the IPAQ, and it is well known that other questionnaires or objective PA measures may yield different results.[38,39] Particularly, studies show that IPAQ overestimates PA level when compared with data derived from accelerometers.[40] However, the use of interviews instead of only using self-reports like in this study has an important impact in increasing its validity as showed by a recent meta-analysis.[41,42] Such procedure was used with our data, fruit of the Brazilian and Colombian experience with IPAQ, increasing its credibility.[41,42] Also, non-English versions of IPAQ seem to have a better performance than the English language.[42] Also, the validity concerns related to the IPAQ, mainly its tendency for PA overestimation, are exactly the same on all 9 classification criterion used for comparisons, mitigating its possible impact on our results.

Furthermore, there are other nuances and new criteria for PA promotion that have been discussed more recently and would also impact on the prevalence estimates and the respective agreement analysis. Important issues such as a minimum amount/frequency of strength training,[43] the impact on recommendations compliance whether PA is evaluated by steps/day or by minutes per week[44] or the impact of different minimum bouts duration for PA level classification (10 min, 5 min, or any PA)[3] were not considered in the analysis. Noteworthy, the newest scientific report published by the U.S. Physical Activity Advisory Committee[6] states that episodes of MVPA of any duration may be included to reach PA guidelines, whereas the IPAQ considers only bouts ≥10 minutes. Of note, the use of the IPAQ must consider its measurement properties, either for surveillance or for the evaluation of interventions, mainly due to the reported tendency for overestimation of PAL.[40–42] Those important issues are beyond our objectives but deserve to be addressed on future studies. Although our samples were statistically representative of 3 different populations, there is a limitation on the external validity of our results as all volunteers are from a middle-income country. Also, the IPAQ administration method use in the Brasilia sample was somewhat different of the other two. However, the inclusion of a short interview looking for any IPAQ filling out mistake and the consistency of the data indicate that this slight difference has probably not affected the results. Finally, it must be considered that quantitative analyses of PA recommendation compliance are somewhat limited considering

that PA is a complex behavior to be evaluated only with quantitative approaches.[45]

As there is evidence showing that IPAQ significantly overestimates energy expenditure when compared with data derived from accelerometers,[40] we suggest caution when using the 450 METs standard due to the trend for overestimation shown in our results, as compared with the WHO criterion.

In summary, our results show that including a minimum frequency of PA during the week reduces the prevalence estimates of sufficiently active people around 11%. To illustrate the importance of a 10% difference in PA level in surveillance, we highlight the work of Lee et al,[2] which simulated what would happen if 10% of the world population became active and found that 533,000 deaths/year would be averted. Thus, the impact of using one or another PA recommendation/standard can be impressive and must be considered on surveillance, prevalence comparisons, and on other analysis,[46] such as those related to the cost-effectiveness of reaching or not the PA recommendations.

Conclusion

The IPAQ-based prevalence estimates of physically active adults, and agreement between different recommendations, were significantly affected when a minimum frequency of PA per week was required, resulting on a decrease around −11% in the number of active individuals, irrespective to gender, age, and educational level. VPA did little contribution on PA prevalence estimates, as showed by the lack of difference when VPA minutes where doubled.

References

1. Ekelund U, Steene-Johannessen J, Brown WJ, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet*. 2016;388(10051): 1302–1310. doi:10.1016/S0140-6736(16)30370-1

2. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Impact of physical inactivity on the world's major non-communicable diseases. *Lancet*. 2012;380(9838):219–229. PubMed ID: 22818936 doi:10.1016/S0140-6736(12)61031-9

3. Saint-Maurice PF, Troiano RP, Matthews CE, Kraus WE. Moderate-to-vigorous physical activity and all-cause mortality: do bouts matter? *J Am Heart Assoc*. 2018;7(6):pii: e007678. doi:10.1161/JAHA.117. 007678

4. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *Lancet Glob Health*. 2018;6(10):e1077–e1086. PubMed ID: 30193830 doi:10.1016/S2214-109X(18)30357-7

5. Arem H, Moore SC, Patel A, et al. Leisure time physical activity and mortality: a detailed pooled analysis of the dose-response relationship. *JAMA Intern Med*. 2015;175(6):959–967. PubMed ID: 25844730 doi:10.1001/jamainternmed.2015.0533

6. Physical Activity Guidelines Advisory Committee. *Physical Activity Guidelines Advisory Committee Scientific Report*. Washington, DC: U.S. Department of Health and Human Services; 2018.

7. World Health Organization, ed. *Global Status Report on Noncommunicable Diseases 2010*. Geneva, Switzerland: World Health Organization; 2011.

8. Haskell WL, Lee I-M, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1423–1434. PubMed ID: 17762377 doi:10.1249/mss.0b013e3180616b27

9. U.S. Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans. 2008. https://health.gov/paguidelines/pdf/paguide.pdf. Accessed July 23, 2017.

10. World Health Organization. Global Recommendations on Physical Activity for Health. 2010. http://www.ncbi.nlm.nih.gov/books/NBK305057/. Accessed July 19, 2017.

11. Wijndaele K, Westgate K, Stephens SK, et al. Utilization and harmonization of adult accelerometry data: review and expert consensus. *Med Sci Sports Exerc*. 2015;47(10):2129–2139. PubMed ID: 25785929 doi:10.1249/MSS.0000000000000661

12. Hallal PC, Dumith Sde C, Bastos JP, Reichert FF, Siqueira FV, Azevedo MR. Evolution of the epidemiological research on physical activity in Brazil: a systematic review. *Rev Saúde Pública*. 2007;41(3):453–460. PubMed ID: 17516000 doi:10.1590/S0034-89102007000300018

13. Matsudo S, Araújo T, Matsudo V, et al. Questionário internacional De atividade física (Ipaq): estupo De validade E reprodutibilidade No Brasil. *Rev Bras Atividade Física Saúde*. 2001;6(2):5–18. doi:10.12820/rbafs.v.6n2p5-18

14. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995;273(5):402–407. PubMed ID: 7823386 doi:10.1001/jama. 1995.03520290054029

15. U.S. Department of Health and Human Services. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: National Center for Chronic Disease Prevention and Health Promotion. Office on Smoking and Health; 1996:278.

16. IPAQ RC. Guidelines for data processing and analysis of the International Physical Activity Questioanneire (IPAQ). November 2005. https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVs dGRvbWFpbnx0aGVpcGFxfGd4OjE0NDgxMDk3NDU1YWRlZTM. Accessed July 23, 2017.

17. Scholes S, Bridges S, Ng Fat L, Mindell JS. Comparison of the physical activity and sedentary behaviour assessment questionnaire and the short-form international physical activity questionnaire: an analysis of health survey for England data. *PLoS ONE*. 2016;11(3): e0151647. doi:10.1371/journal.pone.0151647

18. Kesäniemi A, Riddoch CJ, Reeder B, Blair SN, Sørensen TI. Advancing the future of physical activity guidelines in Canada: an independent expert panel interpretation of the evidence. *Int J Behav Nutr Phys Act*. 2010;7:41. doi:10.1186/1479-5868-7-41

19. Tremblay MS, Kho ME, Tricco AC, Duggan M. Process description and evaluation of Canadian Physical Activity Guidelines development. *Int J Behav Nutr Phys Act*. 2010;7:42. PubMed ID: 20459786 doi:10.1186/1479-5868-7-42

20. Delgado-Rodríguez M, Llorca J. Bias. *J Epidemiol Community Health*. 2004;58(8):635–641. doi:10.1136/jech.2003.008466

21. O'Donovan G, Blazevich AJ, Boreham C, et al. The ABC of Physical Activity for Health: a consensus statement from the British Association of Sport and Exercise Sciences. *J Sports Sci*. 2010;28(6):573–591. doi:10.1080/02640411003671212

22. Australian Government Department of Health Population Health Division. Australia's Physical Activity and Sedentary Behaviour Guidelines. October 2014. http://www.health.gov.au/internet/main/publishing.nsf/Content/health-pubhlth-strateg-phys-act-guidelines#apaadult. Accessed July 23, 2017.

23. O'Donovan G, Lee IM, Hamer M, Stamatakis E. Association of "weekend warrior" and other leisure time physical activity

patterns with risks for all-cause, cardiovascular disease, and cancer mortality. *JAMA Intern Med*. 2017;177(3):335–342. doi:10.1001/jamainternmed.2016.8014

24. Shiroma EJ, Lee IM, Schepps MA, Kamada M, Harris TB. Physical activity patterns and mortality: the weekend warrior and activity bouts. *Med Sci Sports Exerc*. 2019;51(1):35–40. PubMed ID: 30138219 doi:10.1249/MSS.0000000000001762

25. Coledam DHC, Ferraiol PF, Pires R, Ribeiro EAG, Ferreira MAC, de Oliveira AR. Agreement between two cutoff points for physical activity and associated factors in young individuals. *Rev Paul Pediatr Orgao Of Soc Pediatr Sao Paulo*. 2014;32(3):215–222. doi:10.1590/0103-0582201432311

26. Arias-Palencia NM, Solera-Martínez M, Gracia-Marco L, et al. Levels and patterns of objectively assessed physical activity and compliance with different public health guidelines in university students. *PLoS ONE*. 2015;10(11):e0141977. doi:10.1371/journal.pone.0141977

27. de Lima DF, Levy RB, Luiz O do C. Recomendações para atividade física e saúde: consensos, controvérsias e ambiguidades. *Rev Panam Salud Pública*. 2014;36:164–170.

28. Scheers T, Philippaerts R, Lefevre J. Compliance with different physical activity recommendations and its association with socio-demographic characteristics using an objective measure. *BMC Public Health*. 2013;13:136. PubMed ID: 23409982 doi:10.1186/1471-2458-13-136

29. Tucker MA, Hargreaves JM, Clarke JC, Dale DL, Blackwell GJ. The effect of caffeine on maximal oxygen uptake and vertical jump performance in male basketball players. *J Strength Cond Res*. 2013;27(2):382–387. doi:10.1519/JSC.0b013e31825922aa

30. Thompson D, Batterham AM, Markovitch D, Dixon NC, Lund AJS, Walhin J-P. Confusion and conflict in assessing the physical activity status of middle-aged men. *PLoS ONE*. 2009;4(2):e4337. PubMed ID: 19183812 doi:10.1371/journal.pone.0004337

31. Tucker JM, Welk GJ, Beyler NK. Physical activity in U.S.: adults compliance with the physical activity guidelines for Americans. *Am J Prev Med*. 2011;40(4):454–461. PubMed ID: 21406280 doi:10.1016/j.amepre.2010.12.016

32. Perri MG, Anton SD, Durning PE, et al. Adherence to exercise prescriptions: effects of prescribing moderate versus higher levels of intensity and frequency. *Health Psychol*. 2002;21(5):452–458. PubMed ID: 12211512

33. Mittleman MA, Maclure M, Tofler GH, Sherwood JB, Goldberg RJ, Muller JE. Triggering of acute myocardial infarction by heavy physical exertion. Protection against triggering by regular exertion. Determinants of myocardial infarction onset study investigators. *N Engl J Med*. 1993;329(23):1677–1683. PubMed ID: 8232456 doi:10.1056/NEJM199312023292301

34. Lerma NL, Cho CC, Swartz AM, Miller NE, Keenan KG, Strath SJ. Isotemporal substitution of sedentary behavior and physical activity on function. *Med Sci Sports Exerc*. 2018;50(4):792–800. PubMed ID: 29140899 doi:10.1249/MSS.0000000000001491

35. Hallqvist J, Möller J, Ahlbom A, Diderichsen F, Reuterwall C, de Faire U. Does heavy physical exertion trigger myocardial infarction? A case-crossover analysis nested in a population-based case-referent study. *Am J Epidemiol*. 2000;151(5):459–467. PubMed ID: 10707914 doi:10.1093/oxfordjournals.aje.a010231

36. de Souto Barreto P, Cesari M, Andrieu S, Vellas B, Rolland Y. Physical activity and incident chronic diseases: a longitudinal observational study in 16 European countries. *Am J Prev Med*. 2017;52(3):373–378. PubMed ID: 27746011 doi:10.1016/j.amepre.2016.08.028

37. Jeong HG, Kim DY, Kang DW, et al. Physical activity frequency and the risk of stroke: a nationwide cohort study in Korea. *J Am Heart Assoc*. 2017;6(9):pii: e005671. doi:10.1161/JAHA.117.005671

38. Herrmann SD, Heumann KJ, Der Ananian CA, Ainsworth BE. Validity and reliability of the global physical activity questionnaire (GPAQ). *Meas Phys Educ Exerc Sci*. 2013;17(3):221–235. doi:10.1080/1091367X.2013.805139

39. Celis-Morales CA, Perez-Bravo F, Ibañez L, Salas C, Bailey MES, Gill JMR. Objective vs self-reported physical activity and sedentary time: effects of measurement method on relationships with risk biomarkers. *PLoS ONE*. 2012;7(5):e36345. PubMed ID: 22590532 doi:10.1371/journal.pone.0036345

40. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. *Int J Behav Nutr Phys Act*. 2011;8:115. PubMed ID: 22018588 doi:10.1186/1479-5868-8-115

41. Hallal PC, Gomez LF, Parra DC, et al. Lessons learned after 10 years of IPAQ use in Brazil and Colombia. *J Phys Act Health*. 2010;7(suppl 2):S259–S264. doi:10.1123/jpah.7.s2.s259

42. Kim Y, Park I, Kang M. Convergent validity of the international physical activity questionnaire (IPAQ): meta-analysis. *Public Health Nutr*. 2013;16(3):440–452. PubMed ID: 22874087 doi:10.1017/S1368980012002996

43. Carlson SA, Fulton JE, Schoenborn CA, Loustalot F. Trend and prevalence estimates based on the 2008 physical activity guidelines for Americans. *Am J Prev Med*. 2010;39(4):305–313. PubMed ID: 20837280 doi:10.1016/j.amepre.2010.06.006

44. Chastin SFM, Dall PM, Tigbe WW, et al. Compliance with physical activity guidelines in a group of UK-based postal workers using an objective monitoring technique. *Eur J Appl Physiol*. 2009;106(6):893–899. PubMed ID: 19488779 doi:10.1007/s00421-009-1090-x

45. Silva KS, Garcia LMT, Rabacow FM, de Rezende LFM, de Sá TH. Physical activity as part of daily living: moving beyond quantitative recommendations. *Prev Med*. 2017;96:160–162. PubMed ID: 27840115 doi:10.1016/j.ypmed.2016.11.004

46. Warburton DER, Bredin SSD. Reflections on physical activity and health: what should we recommend? *Can J Cardiol*. 2016;32(4):495–504. PubMed ID: 26995692 doi:10.1016/j.cjca.2016.01.024