Author(s): Kujala, Urho; Pietilä, J.; Myllymäki, Tero; Mutikainen, Sara; Föhr, Tiina; Korhonen, I.; Helander, E.

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Urho M. Kujala[1], Julia Pietilä[2], Tero Myllymäki[3], Sara Mutikainen[1],
Tiina Föhr[1], Ilkka Korhonen[2], and Elina Helander[2]

[1]Department of Health Sciences, University of Jyväskylä, Jyväskylä, FINLAND
[2]Department of Signal Processing, Tampere University of Technology, Tampere, FINLAND
[3]Department of Psychology, University of Jyväskylä, Jyväskylä, FINLAND

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Urho M. Kujala[1], Julia Pietilä[2], Tero Myllymäki[3], Sara Mutikainen[1],
Tiina Föhr[1], Ilkka Korhonen[2], Elina Helander[2]

[1]*Department of Health Sciences, University of Jyväskylä, Jyväskylä, FINLAND;* [2]*Department of Signal Processing, Tampere University of Technology, Tampere, FINLAND;* [3]*Department of Psychology, University of Jyväskylä, Jyväskylä, FINLAND*

Corresponding Author: Urho M. Kujala, MD, Department of Health Sciences, University of Jyväskylä, P.O.Box 35 (LL), FI-40014 University of Jyväskylä, Finland

Tel: +358408053567, Fax: +35814617423, E-mail: urho.m.kujala@jyu.fi

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Running title: Physical activity intensity classification

ABSTRACT

Purpose: To investigate in a real-life setting how moderate and vigorous intensity physical activity (PA) volumes differ according to absolute intensity recommendation and relative to individual fitness level by sex, age, and body mass index (BMI). **Methods:** 23 224 Finnish employees (10 201 men, 13 023 women; ages 18-65 years; BMI 18.5-40.0 kg/m^2) participated in heart rate recording for 2+ days. We used heart rate and its variability, respiration rate, and on/off response information from R-R interval data calibrated by participant characteristics to objectively determine daily PA volume, as follows: daily minutes of absolute moderate (3-<6 multiples of resting metabolic rate; METs) and vigorous (≥6 METs) PA; and minutes relative to individual aerobic fitness for moderate (40-<60% of oxygen uptake reserve) and vigorous (≥60%) PA. **Results:** According to absolute intensity categorization, the volume of both moderate and vigorous PA was higher in men compared to women (P < .001), in younger compared to older participants (P < .001), and in normal weight compared to overweight or obese participants (P < .001). When the volume of PA intensity was estimated relative to individual fitness level, the differences were much smaller. Mean daily minutes of absolute intensity vigorous PA were higher than those of relative intensity minutes in normal weight men ages 18-40 years (17.7, 95% CI 16.9-18.6 *vs.* 8.6, 95% CI 8.0-9.1; P < .001), but the reverse was the case for obese women ages 41-65 years (0.3, 95% CI 0.2-0.4 *vs.* 7.8, 95% CI 7.2-8.4; P < .001). **Conclusion:** Compared to low fit persons, high fit persons more frequently reach an absolute target PA intensity, but reaching the target is more similar for relative intensity.

Key Words: EXERCISE, OBJECTIVE MONITORING, HEART RATE, FITNESS

INTRODUCTION

Increasing physical activity (PA) among both healthy people and individuals with chronic disease is linked to many health benefits (22,26,27). The current PA guidelines for aerobic PA (27,39) recommend at least 150 min of moderate intensity PA (MPA) or at least 75 min of vigorous intensity PA (VPA) per week, accumulated in bouts of at least 10 minutes in duration. This recommendation is based mostly on observational cohort studies that most often used self-reported questionnaire measures of leisure-time PA. Results of accelerometer based (1,7,36) and heart rate –based (23) objective assessments of PA indicate that only a small proportion of adult populations meet the recommendation. PA bouts shorter than 10 minutes, often occurring during daily life and unplanned (38), are not included when investigating who fulfills this PA recommendation. However, accumulating evidence suggests that short bouts of moderate-to-vigorous PA (MVPA) are associated with reduced levels of cardiometabolic risk factors (6,12,33,38).

PA can be assessed using questionnaires or more objective monitoring methods (34). Recent advances in accelerometer-based PA monitoring techniques help yield good estimates of the intensity of certain types of PA, such as walking and running on a standard surface (37). Heart rate–based monitoring methods, however, are better for determining the intensity of different types of 'real-life' MVPA (34), including bicycling and many work-related activities. Accelerometer-based objective monitoring methods may be more reliable in recording low to very low intensity PA compared to simple heart rate–based devices because of artifacts resulting from excitement and other stimuli unrelated to PA that still influence heart rate (34). The current aerobic PA recommendations are for MVPA characterized in absolute multiples of resting metabolic rate, metabolic equivalent (MET), values. However, maximal exercise capacity in low-fit individuals, in particular among those who are older, obese, or have chronic disease, may be lower than the recommended absolute intensity level of VPA. Consequently, individuals who cannot reach the recommended intensity level do not have this type of PA recorded. Physicians and other professionals giving exercise recommendations need to understand which types of PA are achievable by physically inactive people with low fitness levels, the most important target group for PA promotion. Although variation exists in how people feel pleasure and discomfort when they exercise at different intensity levels, in general, pleasure is reduced when the ventilatory or lactate threshold is surpassed (8).

The aim of this study was to compare the volumes of objectively monitored PA determined by recommended absolute intensity levels and by intensity levels relative to individual fitness by sex, age, and body mass index (BMI) (normal weight, overweight, obese) among 23 224 Finnish employees during everyday life. To determine the PA volumes, we used sophisticated and validated methodology (25), including information on continuous heart rate and heart rate variability recordings.

METHODS

Study design and participants. This cross-sectional study investigated the amount of absolutely and relatively (i.e., relative to participant's maximal oxygen uptake [VO_{2max}]) determined PA at different intensity levels (moderate, vigorous, and moderate-to-vigorous combined) during workdays and days off by sex, age, and BMI among a sample of 23 224 Finnish employees (10 201 men and 13 023 women; age range 18-65 years; BMI range 18.5-

40.0 kg/m^2) who participated in 'real life' preventive occupational health care provided by their employers during the years 2007-2015 in Finland (Figure 1). A wide non-selective range of non-manual and manual labor employees was included. The employees participated in real-life continuous beat-to-beat R-R interval recordings. The majority of participants were apparently healthy because individuals with chronic disease and medications influencing heart rate did not participate in these recordings. For detailed exclusion criteria for participation in the R-R interval recordings, see Mutikainen et al. (25).

The data obtained from these R-R interval recordings were anonymously stored in a database administered by the software manufacturer (Firstbeat Technologies Ltd, Jyväskylä, Finland). According to written agreements (25), Firstbeat Technologies Ltd extracted an anonymous data file for the present research purposes. This study was approved by the Ethics Committee of Tampere University Hospital (Reference No R13160).

PA monitoring and assessment. The ambulatory beat-to-beat R-R interval data used to calculate the intensity and amount of PA were recorded during the course of normal everyday life, usually over 3 days (typically including two workdays and one day off), using the Firstbeat Bodyguard device with stick-on electrodes with wires (Firstbeat Technologies Ltd). Monitoring data were first analyzed using Firstbeat Analysis Server software (version 6.3, Firstbeat Technologies Ltd). To be included, a participant had to have a measurement period including at least one workday and one day off (Figure 1). We included a workday or a day off in the analysis if the measurement period lasted 16-30 h/day. Because the measurement day was determined from waking up to waking up, recordings were allowed to exceed 24 hours. The information about the type of day was obtained from participant diaries; a workday had to include ≥4 working hours cumulatively, days off were without any working hours, and the days with reported work time >0 but <4 hours were excluded from the analyses. The analyzed data consisted of successfully recorded (measurement error in recording R-R intervals detected with an automatic artefact detection and correction feature for irregular ectopic beats, and signal noise <15% and <30 minutes recording break) workdays and days off (Figure 1).

Background information included age, sex, questionnaire-reported height, weight, and PA class (9), modified from Ross and Jackson (29). Then, maximal heart rate (210 – 0.65 × age) (16) and VO_{2max} (men 67.350 + 1.921 × PA class – 0.381 × age – 0.754 × BMI; women 56.363 + 1.921 × PA class – 0.381 × age – 0.754 × BMI) (15) were estimated, and these values were further used in the estimation of oxygen uptake (VO_2). If a period with a heart rate higher than the estimate was found from the recording, the maximal heart rate used for further calculations was corrected accordingly. BMI (kg/m^2) was calculated from the self-reported weight and height.

The intensity in terms of VO_2 and volume of PA was first estimated based on the R-R interval recordings (10,17,18,30). The method has been validated previously; the pooled relationship (correlation) between the measured and predicted VO_2 across the different activities of daily living was 0.93, and the estimated VO_2 explained 87% of the variability in the measured VO_2 (32). In another validation study Robertson et al (28) showed that the energy expenditure estimates based on our method correlate strongly with those based on indirect calorimetry across analysis conditions (r=0.85-0.98). The high validity of this method was achieved by taking into account the R-R interval–derived information about heart rate, respiration rate, and on/off response (increasing or decreasing heart rate) using neural network modeling of the data and the short-time Fourier transform method (10,17,18,30).

Participant mean VO_2 for each minute was calculated from the second-by-second VO_2 estimations. For the calculation of the volume of absolutely determined PA, the minute-by-minute VO_2 estimations were converted to METs by dividing the VO_2 values by a resting metabolic rate value of 3.5 ml/kg/min. Based on the MET values, the volume of MPA and VPA (minutes/day) at each intensity level was then calculated. These data are referred to as MPA_{Abs} and VPA_{Abs} later in the text. The thresholds for these categories were MPA_{Abs} 3-<6 METs and VPA_{Abs} ≥6 METs (11). MVPA then refers to the sum of MPA and VPA, respectively.

The intensity of PA was also calculated relatively, i.e., in relation to estimated VO_{2max}. The relative intensity was determined using the percentage of VO_2 reserve (%VO_2R). VO_2R is calculated by subtracting 1 MET (3.5 ml/kg/min) from the VO_{2max}. The %VO_2R is calculated by subtracting 1 MET from the measured VO_2, dividing by the VO_2R, and multiplying by 100% (14). The amount of PA (min/day) at different intensity levels (moderate, vigorous) was then calculated. These values are referred to as MPA_{Rel} and VPA_{Rel} later in the text. The thresholds for these categories were MPA_{Rel} 40-<60% VO_2R and VPA_{Rel} ≥60% VO_2R (11,14). Again, MVPA refers to the sum of MPA and VPA, respectively.

As the general use of resting metabolic rate value of 3.5 ml/kg/min to calculate PA METs for individuals with differing sex, age and BMI may cause misclassification of activities

(20) we also recalculated the main results using the original Harris-Benedict formula (13). Results in our paper and Supplemental Digital Content 1, http://links.lww.com/MSS/A810, are based on the generally used 3.5 ml/kg/min for resting metabolic rate and those in the Supplemental Digital Content 2, http://links.lww.com/MSS/A811, on calculating the resting metabolic rates using the Harris-Benedict formula.

Statistical analysis. Data processing and statistical analysis were performed using MATLAB version R2015b (The MathWorks Inc., Natick, MA, USA) and R version 3.2.2 (The R Foundation for Statistical Computing, Vienna, Austria).

We calculated means, standard deviations (SDs), and 95% confidence intervals (CIs) for continuous variables. First, the total number of one-minute segments in each intensity category during each measurement day for each individual was calculated. If a participant's measurement period included two or more workdays (or days off), an average was calculated. We also calculated the mean daily absolute and relative intensity PA minutes covering both workdays and days off. Then, we calculated the amount of MPA_{Abs}, MPA_{Rel}, VPA_{Abs}, and VPA_{Rel} by gender and type of day (i.e., workdays vs. days off) for different age (18-30, 31-40, 41-50, and 51-65 years) and BMI categories (normal weight 18.5 to <25.0 kg/m^2, overweight 25.0 to <30.0 kg/m^2, and obese 30.0 to 40.0 kg/m^2). The absolute and relative PA volumes at different intensity levels were compared inside each age and BMI category using the Wilcoxon signed rank test. Differences in the absolute and relative PA volumes between age and BMI categories were analyzed using the Kruskal-Wallis test.

We then calculated how the determined absolute and relative intensity PA minutes overlapped (Figures 2 and 3). In addition, we calculated at the group level the proportions between VPA_{Abs}/VPA_{Rel} in specific subgroups (Figure 4). Because of the complexity of the relations between the absolute and relative intensity minutes, the 95% CIs for the relations were calculated using a percentile bootstrapping method. All *P* values reported are two-sided, and because of the large sample size, the significance level was set to .001.

RESULTS

Most of the R-R-interval recordings were from values taken over 3 days (13 052 participants); 7062, 1327, 936, and 847 participants had 2, 4, 5, and 6 measurement days, respectively. Altogether, the number of analyzed days was 39 904 for workdays and 28 446 for days off (Figure 1). The mean (SD) age of the participants was 44.7 (9.8) years [men 44.4 (9.9); women 45.0 (9.8)], and the mean (SD) BMI was 26.0 (4.0) kg/m^2 [men 26.6 (3.5); women 25.5 (4.4)] (Table 1).

Heart rates and estimated VO_{2max}. Mean heart rates did not differ substantially between age groups or between workdays and days off. However, the mean heart rates increased with increasing BMI among both men and women during both workdays and days off, covering time awake and sleeping time (see Table 1 in Supplemental Digital Content 1, Mean heart rates by age, sex, and type of day during whole recording day, http://links.lww.com/MSS/A810). For the estimated mean VO_{2max} values by sex, age and BMI categories, see Table 2 in Supplemental Digital Content 1 (Mean estimated VO_{2max} values by sex, age and weight group, http://links.lww.com/MSS/A810).

PA volumes by sex, age, and type of day. According to absolute intensity, as expected, men had higher values for MPA and VPA minutes than women (Table 2). The means for the $MVPA_{Abs}$ minutes during workdays were 50.5 (95% CI 49.5-51.4) for men and 33.2 (95% CI 32.6-33.8) for women ($P < .001$); during days off, they were 63.7 (62.5-64.9) and 34.7 (34.0-35.4) ($P < .001$), respectively [see Tables 3 and 4 in Supplemental Digital Content 1, Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups during workdays and days off among men; Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups during workdays and days off among women, http://links.lww.com/MSS/A810]. In particular, VPA volumes were low for women (Table 2). However, when calculated as intensity levels relative to individual fitness, the PA volumes for women were about at the same level as for men or even higher (Table 2): mean daily minutes of $MVPA_{Rel}$ were 16.2 for men and 17.3 for women.

Men over age 30 years had higher $MVPA_{Abs}$ and $MVPA_{Rel}$ minutes during days off than during workdays, but these differences were not as strong in women and in younger men. PA volume in terms of absolute intensity decreased by age among both women and men, during both workdays and days off, but a similar strong age-related reduction of PA was not seen when the intensity was calculated relative to individual fitness level [Table 2, see also Tables 3 and 4 in Supplemental Digital Content 1, Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups during workdays and days off among men; Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups during workdays and days off among women, http://links.lww.com/MSS/A810.].

Among the oldest women (51-65 y), the amount of VPA_{Rel} was higher compared with VPA_{Abs} ($P < .001$).

The overlap of the minutes that fulfilled the criteria for either $MVPA_{Abs}$ or $MVPA_{Rel}$ in different absolute and relative intensity categories is shown in Figure 3. An average of 9.7% (95% CI 9.5-9.9) of these minutes were vigorous and 19.7% (95% CI 19.4-20.0) were moderate intensity, according to both absolute and relative criteria.

PA volumes and BMI. The amount of PA in terms of absolute intensity decreased with increasing BMI among both women and men. However, a similar strong BMI-related reduction of PA was not seen when the intensity was calculated relative to individual fitness level [Table 2, see also Tables 5 and 6 in Supplemental Digital Content 1, Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by weight status during workdays and days off among men; Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by weight status during workdays and days off among women, http://links.lww.com/MSS/A810]. In men, the volume of MPA_{Rel} was significantly lower than that of MPA_{Abs} ($P < .001$) in each BMI category. Except for obese men during days off, the amount of VPA_{Rel} also was significantly ($P < .001$) lower than VPA_{Abs} in each BMI category among men.

Among women, the volume of MPA_{Rel} was significantly ($P < .001$) lower than MPA_{Abs} in each BMI category. However, among overweight and obese women, the amount of VPA_{Rel} was significantly ($P < .001$) higher than VPA_{Abs}. Of note, among obese women, 93%

during workdays and 95% during days off had no VPA_{Abs}, with percentages of 41% and 54% for no VPA_{Rel}, respectively.

Mean daily VPA_{Abs} minutes were higher than VPA_{Rel} minutes in younger (18-40 y) normal weight men (17.7, 95% CI 16.9-18.6 *vs.* 8.6, 95% CI 8.0-9.1; $P < .001$). The reverse was the case for older (41-65 y) obese women (mean 0.3, 95% CI 0.2-0.4 *vs.* 7.8, 95% CI 7.2-8.4; $P < .001$).

Figure 4 shows the relations between all VPA_{Rel}/VPA_{Abs} minutes among younger (18-40 y) and older (41-65 y) men and women split into smaller BMI categories. The number of VPA_{Rel} minutes was higher than the number of VPA_{Abs} minutes among older men with BMI over 34, younger women with BMI over 28, and older women with BMI over 20. Concerning the overlap of the absolute *vs.* relative intensity minute categories (Figure 3), among normal weight men, there were no minutes in the category of below-MPA_{Abs} but $MVPA_{Rel}$ but an average of 27.7% of the recorded PA minutes fell into these categories among obese women.

When reanalyzing the main results using resting metabolic rate calculated individually according to the Harris-Benedict formula, expectedly, the resting metabolic rates were lower than 3.5, in particular among aged, obese females [for details see Table 1 in Supplemental Digital Content 2, Mean estimated resting metabolic rates (VO_2 values) by sex, age and weight groups according to Harris-Benedict formula, http://links.lww.com/MSS/A811]. In this reanalysis, the number of absolute PA minutes was higher [please, compare Table 2 in the Supplemental Digital Content 2 (Mean estimated resting metabolic rates (VO_2 values) by sex, age and weight groups according to Harris-Benedict formula) vs. Table 2 in the manuscript, http://links.lww.com/MSS/A811]. The overlap of the minutes that fulfilled the criteria for either $MVPA_{Abs}$ or $MVPA_{Rel}$ in different absolute and relative intensity categories was lower than that in our primary analysis [see Figure 1 in Supplemental Digital Content 2 (Overlap between absolute PA intensity *vs.* PA intensity relative to individual aerobic fitness level) vs. Figure 3, http://links.lww.com/MSS/A811] and the number of VPA_{Rel} minutes persisted higher than the number of VPA_{Abs} minutes in particular among older women with high BMI.

DISCUSSION

Objectively measured absolute volumes of MVPA were higher in men than women in this study, and higher in younger compared to older and in normal weight compared to obese individuals. When the moderate and vigorous PA volumes were categorized according to $\%VO_2R$, the differences were not as stark. The mean cardiovascular strain, when indicated with mean heart rate during all of the recording days, was higher among individuals with higher BMI.

As many of our participants were physically fit and usually healthy employed individuals, the absolute PA volumes were higher compared to relative volumes in many of the studied age and body weight categories (Table 2). The findings on the ratios between absolute *vs.* relative PA volumes according to age and sex reflect the previously reported international (31) and Finnish (24) results on the distribution of measured population fitness. It was rather easy for high-fit individuals to reach moderate-to-vigorous PA intensity levels according to absolute criteria compared to criteria relative to individual fitness level, but the situation reversed among the unfit individuals. This phenomenon was similar during days off and workdays. Our findings are in line with data from US adults showing that vigorous PA determined in absolute terms using an accelerometry method is low among older, female, and obese individuals (36).

Because we are not aware of large population studies of overlap between absolute and relative intensity PA volumes, we cannot compare our results with other studies. In PA counseling, the intensity of PA should be tailored individually (11), but this recommendation is often ignored in practice. When trying to find effective solutions to increase PA among physically inactive low-fit individuals, we need to take into account the individual fitness level to focus on behavior changes that are easy to adopt and sustain, rather than expect people to become highly motivated to adopt and maintain effortful behaviors that include too vigorous PA. In PA counseling, appropriate PA intensity may be guided most easily by using simple terms describing exercise intensity or using Borg Rating of Perceived Exertion scale (from 6-20) (3) where 12-13 indicates moderate and 14 or more vigorous PA. Heart rate monitoring during exercise would be a more accurate alternative to guide and control target exercise intensity. Individuals with severe chronic disease usually need personal advice from health care professionals and related to medical clearance for exercise participation/rehabilitation the intensity levels are usually given in a way proper for each condition, such as determination of symptom-free exercise intensities among patients with heart disease. In a previous 'real-life' lifestyle intervention, increasing PA was a good indicator of success in improving the cardiovascular and metabolic risk factor levels including body weight reduction (23).

Strengths and limitations. Although we did not have direct oxygen uptake recordings in our large 'real-life' data, we used a validated ambulatory method to assess the intensity of PA. This method provides more accurate estimates of the intensity of PA compared to heart rate information only (32). The use of % VO_2R is relatively valid also among obese individuals (5) and patients with heart disease (4). However, there are no specific validation studies comparing the validity of our methodology between representative body-mass index and age groups. Our recordings had good coverage of typical workdays and days off.

Our study was a cross-sectional study. Randomized controlled trials are needed to confirm that PA recommended with guidelines applying subjective intensity levels is more feasible in the long term compared to those using absolute intensity levels in the important target group of low-fit formerly inactive overweight and obese individuals. Although moderate intensity PA relative to individual fitness level improves fitness (35) and other cardiometabolic risk factor levels (19) among low-fit individuals, a comprehensive understanding about which PA intensity is most beneficial for health in the long term is still lacking.

CONCLUSIONS

Compared to low-fit individuals, it is easier for high-fit individuals to reach moderate-to-vigorous PA intensity levels according to absolute criteria and easier for men compared to women, younger people compared to older, and lean compared to obese individuals. When the target is set as relative intensity the frequency of reaching the target is more similar in low and high fit individuals. So, when boosting moderate-to-vigorous PA in inactive, low-fit, and/or obese individuals, intensity guidelines relative to individual fitness may be more feasible than using recommended absolute intensity classifications. Because PA counseling is suggested to be made a priority in clinical practice (2,21), our findings should be considered when taking action in the most important target group of low-fit individuals. Also, our findings need to be taken into account when interpreting the results of population studies that have used accelerometer-based monitoring of PA volumes with absolute criteria.

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Myllymäki reports being employed also by Firstbeat Technologies Ltd, Jyväskylä, Finland, and Korhonen reports being employed also by PulseOn Oy, Espoo, Finland. Authors have no other conflicts of interest to declare.

The results of the present study do not constitute endorsement by the American College of Sports Medicine.

The authors declare that the results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

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Figure legends

FIGURE 1. Flow of participants and measurement days included in the analysis.

FIGURE 2. Illustration of the theoretical overlap between absolute PA intensity *vs.* PA intensity relative to individual aerobic fitness level.

Abbreviations: PA = physical activity; MET = multiples of the resting metabolic rate; $\%VO_2$ reserve = percentage of maximal oxygen uptake reserve

FIGURE 3. Overlap (mean percent of PA minutes falling in different intensity categories) between absolute PA intensity *vs.* PA intensity relative to individual aerobic fitness level.

For abbreviation, see FIGURE 2.

FIGURE 4. Daily VPA_{Abs}/VPA_{Rel} minute ratios among older and younger men and women by body mass index categories.

Abbreviations: PA = physical activity; VPA_{Abs} = daily minutes of absolute vigorous (≥6 METs; multiples of resting metabolic rate, METs) intensity PA. VPA_{Rel} = daily minutes of vigorous intensity PA relative to individual aerobic fitness (≥60% of oxygen uptake reserve). Error bars represent 95% CIs.

Supplemental Digital Content 1:

TABLE 1. Mean heart rates by age, sex, and type of day during whole recording day.

TABLE 2. Mean estimated VO_{2max} values by sex, age and weight group.

TABLE 3. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups during workdays and days off among men.

TABLE 4. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups during workdays and days off among women.

TABLE 5. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by weight status during workdays and days off among men.

TABLE 6. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by weight status during workdays and days off among women.

Supplemental Digital Content 2:

All results in Supplemental Digital Content 2 are based on calculating resting metabolic rate individually using the Harris-Benedict formula.

TABLE 1. Mean estimated resting metabolic rates (VO_2 values) by sex, age and weight groups according to Harris-Benedict formula.

TABLE 2. The mean daily amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups and by weight status among men and women.

FIGURE 1. Overlap (mean percent of PA minutes falling in different intensity categories) between absolute PA intensity *vs.* PA intensity relative to individual aerobic fitness level.

Figure 1

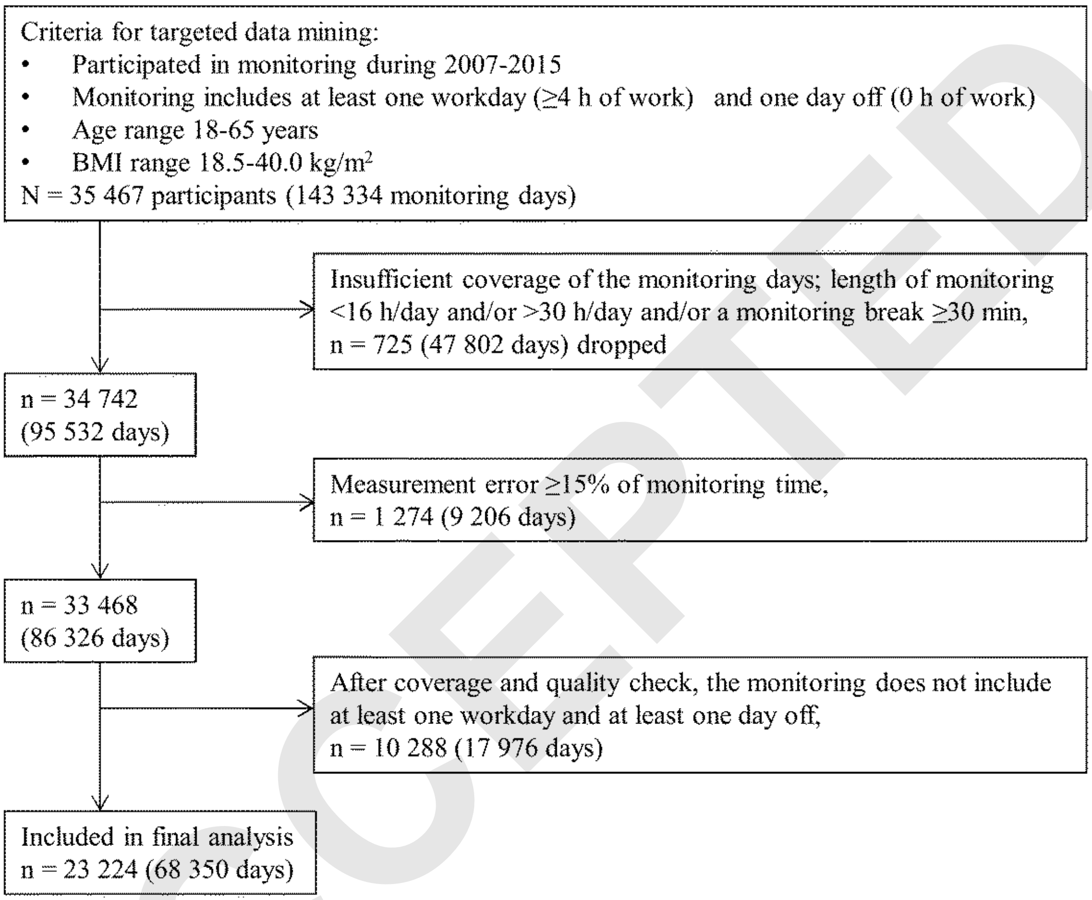
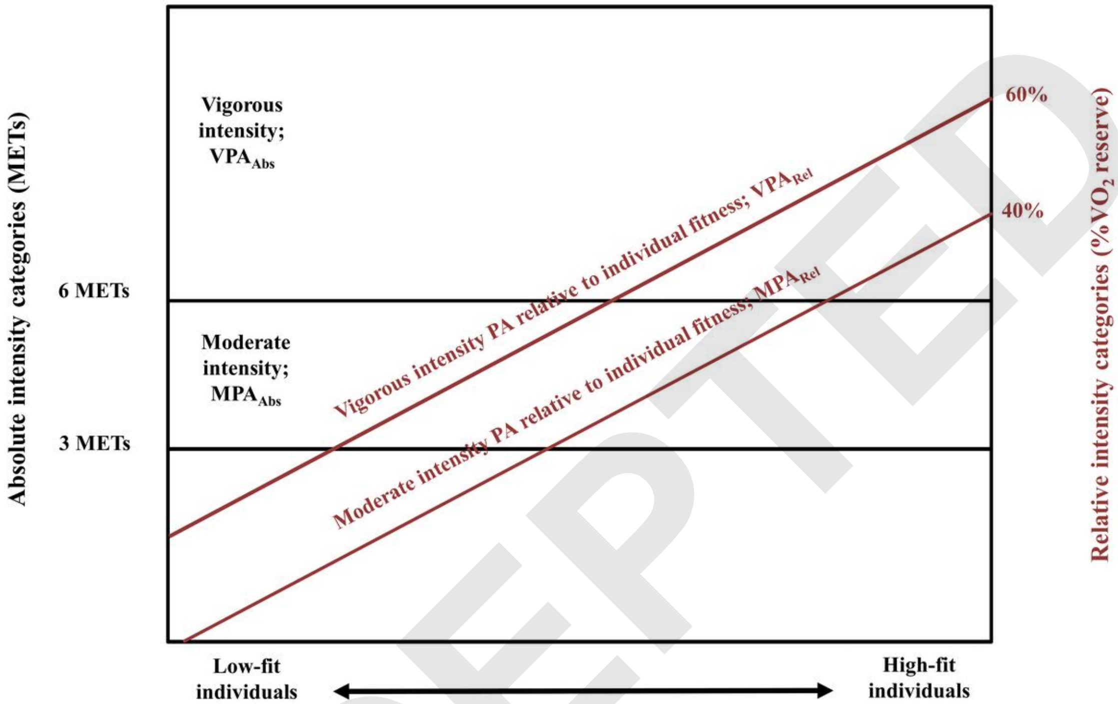
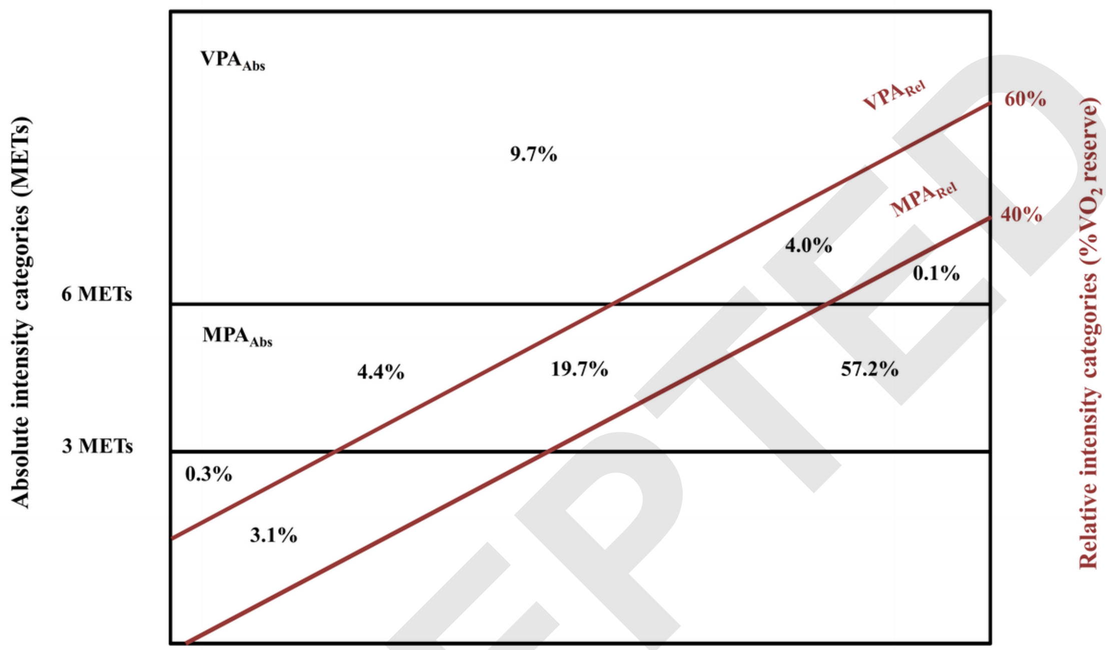

Criteria for targeted data mining:
• Participated in monitoring during 2007-2015
• Monitoring includes at least one workday (≥4 h of work) and one day off (0 h of work)
• Age range 18-65 years
• BMI range 18.5-40.0 kg/m^2
N = 35 467 participants (143 334 monitoring days)
Insufficient coverage of the monitoring days; length of monitoring <16 h/day and/or >30 h/day and/or a monitoring break ≥30 min,
n = 725 (47 802 days) dropped
n = 34 742
(95 532 days)
Measurement error ≥15% of monitoring time,
n = 1 274 (9 206 days)
n = 33 468
(86 326 days)
After coverage and quality check, the monitoring does not include at least one workday and at least one day off,
n = 10 288 (17 976 days)
Included in final analysis
n = 23 224 (68 350 days)

Figure 2



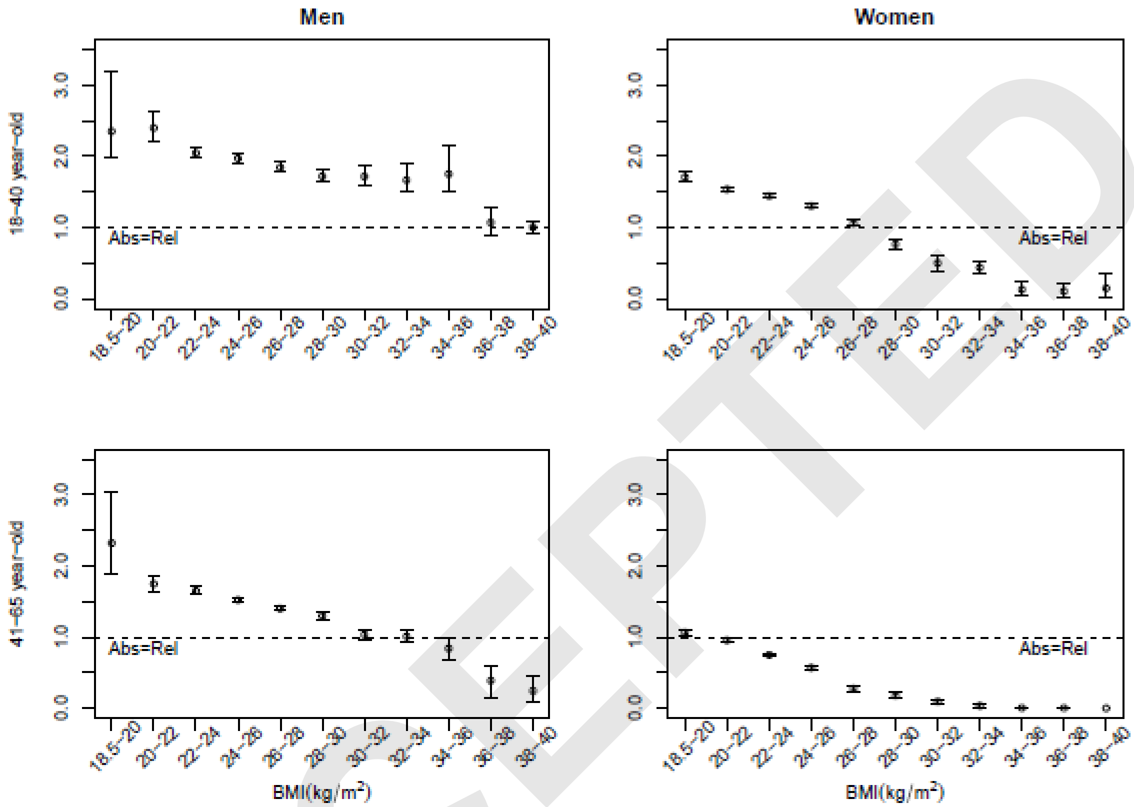
Vigorous intensity; VPA_{Abs}
Moderate intensity; MPA_{Abs}
6 METs
3 METs
Absolute intensity categories (METs)
Vigorous intensity PA relative to individual fitness; VPA_{Rel}
Moderate intensity PA relative to individual fitness; MPA_{Rel}
60%
40%
Relative intensity categories (% VO_2 reserve)
Low-fit individuals
High-fit individuals

Figure 3



VPA$_{Abs}$
9.7%
VPA$_{Rel}$
60%
MPA$_{Rel}$
40%
4.0%
0.1%
6 METs
MPA$_{Abs}$
4.4%
19.7%
57.2%
3 METs
0.3%
3.1%
Absolute intensity categories (METs)
Relative intensity categories (% VO_2 reserve)

Figure 4



Men
Women
18–40 year-old
41–65 year-old
Abs=Rel
0.0
1.0
2.0
3.0
18.5–20
20–22
22–24
24–26
26–28
28–30
30–32
32–34
34–36
36–38
38–40
BMI(kg/m2)

TABLE 1. Number of participants by sex, age, and weight status

Age group	n	Normal weight	Overweight	Obese
		Weight status		
		% (n)		
18-30 y				
Men	940	54.0 (524)	36.0 (349)	6.9 (67)
Women	1148	76.0 (873)	17.3 (199)	6.6 (76)
31-40 y				
Men	2794	39.9 (1115)	47.3 (1321)	12.8 (358)
Women	3087	64.6 (1995)	24.3 (751)	11.0 (341)
41-50 y				
Men	3333	31.4 (1048)	51.2 (1708)	17.3 (577)
Women	4512	51.4 (2318)	30.7 (1386)	17.9 (808)
51-65 y				
Men	3134	30.9 (968)	52.5 (1646)	16.6 (520)
Women	4276	44.1 (1887)	35.3 (1511)	20.5 (878)
Total				
Men	10 201	35.8 (3655)	49.3 (5024)	14.9 (1522)
Women	13 023	54.3 (7073)	29.5 (3847)	16.1 (2103)

Normal weight = body mass index 18.5-<25.0 kg/m^2.

Overweight = body mass index 25.0-<30.0 kg/m^2.

Obese = body mass index 30.0-40.0 kg/m^2.

TABLE 2. Mean[a] daily amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups and by weight status among men and women

	MPA_{Abs}	**MPA_{Rel}**	**VPA_{Abs}**	**VPA_{Rel}**	**$MVPA_{Abs}$**	**$MVPA_{Rel}$**
			Mean (95% CI) minutes			
Activity volumes by age groups						
Men						
18-30 y	71.3 (68.3; 74.2)	9.1 (8.5; 9.6)	17.9 (16.8; 18.9)	7.8 (7.1; 8.4)	89.1 (85.7; 92.6)	16.9 (15.8; 17.9)
31-40 y	49.2 (47.9; 50.4)	8.4 (8.1; 8.7)	14.5 (13.9; 15.1)	8.0 (7.6; 8.4)	63.7 (62.1; 65.3)	16.4 (15.8; 17.0)
41-50 y	41.4 (40.4; 42.4)	8.9 (8.5; 9.2)	12.0 (11.5; 12.5)	7.7 (7.3; 8.1)	53.4 (52.2; 54.6)	16.5 (16.0; 17.1)
51-65 y	37.2 (36.2; 38.2)	9.2 (8.9; 9.5)	8.2 (7.8; 8.7)	6.3 (6.0; 6.7)	45.4 (44.3; 46.6)	15.5 (14.9; 16.1)
Women						
18-30 y	55.1 (53.3; 56.8)	12.5 (11.9; 13.0)	15.6 (14.7; 16.4)	9.5 (8.9; 10.1)	70.6 (68.4; 72.8)	21.9 (21.0; 22.9)
31-40 y	34.1 (33.3; 34.9)	9.5 (9.2; 9.8)	8.4 (8.0; 8.8)	7.0 (6.7; 7.3)	42.5 (41.5; 43.5)	16.5 (16.0; 17.0)
41-50 y	25.2 (24.7; 25.7)	9.5 (9.3; 9.8)	5.1 (4.8; 5.4)	6.8 (6.5; 7.0)	30.3 (29.6; 31.0)	16.3 (15.9; 16.7)
51-65 y	19.8 (19.3; 20.3)	10.7 (10.4; 11.0)	2.0 (1.8; 2.2)	6.8 (6.5; 7.1)	21.8 (21.2; 22.4)	17.5 (17.0; 18.1)
Activity volumes by weight status						
Men						
Normal	51.6 (50.4; 52.8)	9.2 (8.9; 9.5)	16.0 (15.5; 16.6)	8.8 (8.4; 9.2)	67.6 (66.2; 69.1)	18.0 (17.5; 18.6)

Overweight	43.0 (42.1; 43.8)	8.6 (8.3; 8.8)	11.0 (10.6; 11.4)	7.0 (6.7; 7.3)	54.0 (53.0; 55.0)	15.6 (15.1; 16.0)
Obese	35.8 (34.3; 37.3)	8.8 (8.4; 9.3)	6.1 (5.5; 6.6)	5.2 (4.7; 5.7)	41.9 (40.2; 43.6)	14.0 (13.2; 14.8)
Women						
Normal	35.3 (34.7; 35.9)	10.4 (10.2; 10.5)	9.1 (8.8; 9.3)	8.2 (7.9; 8.4)	44.4 (43.7; 45.1)	18.5 (18.2; 18.9)
Overweight	22.8 (22.2; 23.4)	9.2 (9.0; 9.5)	2.6 (2.4; 2.7)	5.0 (4.8; 5.3)	25.3 (24.7; 26.0)	14.2 (13.8; 14.7)
Obese	14.0 (13.4; 14.6)	11.3 (10.8; 11.8)	0.6 (0.4; 0.7)	7.1 (6.6; 7.6)	14.6 (14.0; 15.2)	18.4 (17.5; 19.3)
All men	45.0 (44.4; 45.6)	8.9 (8.7; 9.0)	12.1 (11.8; 12.4)	7.4 (7.2; 7.6)	57.1 (56.3; 57.9)	16.2 (15.9; 16.6)
All women	28.2 (27.8; 28.5)	10.2 (10.0; 10.3)	5.8 (5.6; 5.9)	7.1 (6.9; 7.2)	33.9 (33.5; 34.4)	17.2 (17.0; 17.5)

[a]Mean of all monitored work days and days off.

There was a statistically significant difference between absolute and relative intensity physical activity ($P < .001$, Wilcoxon signed rank test) in all age groups and weight status groups and intensity categories.

Except for MPA_{Rel} in men ($P = .006$), there was a statistically significant difference ($P < .001$, Kruskal-Wallis test) in all intensity categories between age groups.

There was a statistically significant difference ($P < .001$, Kruskal-Wallis test) in all activity types between weight status groups.

Abbreviations: MPA_{Abs} = moderate physical activity, absolutely determined intensity: 3.0-<6.0 metabolic equivalents (METs); MPA_{Rel} = moderate physical activity, relatively determined intensity: 40-<60% oxygen uptake reserve (VO_2R); VPA_{Abs} = vigorous physical activity, absolutely determined intensity: ≥6.0 METs; VPA_{Rel} = vigorous physical activity, relatively determined intensity: ≥60% VO_2R; MVPA = moderate-to-vigorous physical activity combined, respectively.

Normal = body mass index 18.5-<25.0 kg/m^2.

Overweight = body mass index 25.0-<30.0 kg/m^2.

Obese = body mass index 30.0-40.0 kg/m^2.

Supplemental Digital Content 1

Kujala UM, Pietilä J, Myllymäki T, et al. Physical Activity: Absolute Intensity vs. Relative-to-Fitness-Level Volumes

TABLE 1. Mean heart rates by age, sex, and type of day during whole recording day.

TABLE 2. Mean estimated VO_{2max} values by sex, age and weight group.

TABLE 3. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups during workdays and days off among men.

TABLE 4. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups during workdays and days off among women.

TABLE 5. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by weight status during workdays and days off among men.

TABLE 6. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by weight status during workdays and days off among women.

This supplementary material has been provided by the authors to give readers additional information about their work.

TABLE 1. Mean heart rates by sex, age, weight group and type of day during whole recording day.[a]

	Men		Women	
	Workdays	Days off	Workdays	Days off
	Mean (95% CI)			
Heart rates by age groups				
18-30 y	72.3 (71.8-72.8)	73.0 (72.4-73.6)	76.9 (76.4-77.4)	76.8 (76.3-77.3)
31-40 y	71.8 (71.5-72.1)	73.3 (73.0-73.7)	75.9 (75.6-76.1)	75.9 (75.6-76.2)
41-50 y	72.0 (71.7-72.3)	74.0 (73.7-74.3)	75.1 (74.8-75.3)	75.5 (75.3-75.7)
51-65 y	71.1 (70.8-71.3)	72.7 (72.4-73.0)	73.9 (73.7-74.1)	74.3 (74.1-74.5)
Heart rates by weight groups				
Normal	70.1 (69.9-70.4)	71.8 (71.5-72.1)	74.1 (74.0-74.3)	74.7 (74.6-74.9)
Overweight	71.8 (71.6-72.1)	73.4 (73.2-73.7)	75.5 (75.3-75.7)	75.7 (75.4-75.9)
Obese	75.1 (74.7-75.5)	76.6 (76.2-77.1)	77.1 (76.8-77.5)	76.6 (76.3-77.0)

[a]Recordings include both sleeping time and time awake.
The difference in heart rates between age groups was statistically significant ($P < .001$, one-way ANOVA).
The difference in heart rates between weight status groups was statistically significant ($P < .001$, one-way ANOVA).
Except for men ages 18-30 years, the difference in heart rates between workdays and days off was statistically significant ($P < .001$, one-way ANOVA) in men for all age and weight status groups.
The difference in heart rates between workdays and days off was statistically significant ($P < .001$, one-way ANOVA) in women for normal weight status group.
Normal = body mass index 18.5-<25.0 kg/m^2.
Overweight = body mass index 25.0-<30.0 kg/m^2.
Obese = body mass index 30.0-40.0 kg/m^2.

TABLE 2. Mean estimated VO_{2max} values by sex, age and weight group.[a]

	Men	Women
	Mean±SD	
VO_{2max} by age groups		
18-30 y	48.4±4.3	38.9±4.9
31-40 y	43.4±4.7	33.4±5.2
41-50 y	38.9±4.9	28.5±5.4
51-65 y	34.6±4.9	23.7±5.4
VO_{2max} by weigh groups		
Normal	43.6±5.3	32.9±5.5
Overweight	38.9±5.5	26.6±5.2
Obese	32.9±5.5	20.5±5.2

[a]Note that reported physical activity levels also contributed to these values.
The difference in VO_{2max} between age groups was statistically significant ($P < .001$, one-way ANOVA).
The difference in VO_{2max} between weight status groups was statistically significant ($P < .001$, one-way ANOVA).
Normal = body mass index 18.5-<25.0 kg/m^2.
Overweight = body mass index 25.0-<30.0 kg/m^2.
Obese = body mass index 30.0-40.0 kg/m^2.

TABLE 3. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups during workdays and days off among men.

	MPA_{Abs}	MPA_{Rel}	VPA_{Abs}	VPA_{Rel}	$MVPA_{Abs}$	$MVPA_{Rel}$
Workdays						
18-30 y (n = 940)						
mean±SD	71.5±64.5	8.8±10.7	16.7±20.5	7.0±11.5	88.2±74.4	15.8±19.2
95% CI	67.4-75.7	8.1-9.4	15.4-18.0	6.3-7.7	83.5-93.0	14.5-17.0
0 min (%)[a]	0.6	17.7	17.2	42.7	0.6	17.7
31-40 y (n = 2794)						
mean±SD	44.4±42.3	7.2±9.4	12.2±17.6	6.7±12.0	56.6±49.4	13.9±18.2
95% CI	42.8-46.0	6.9-7.6	11.6-12.9	6.2-7.1	54.8-58.5	13.2-14.6
0 min (%)[a]	1.1	22.5	30.2	48.7	1.0	22.2
41-50 y (n = 3333)						
mean±SD	35.4±34.7	7.2±9.7	9.8±15.7	6.1±11.4	45.2±41.0	13.4±17.5
95% CI	34.3-36.6	6.9-7.6	9.2-10.3	5.7-6.5	43.8-46.6	12.8-13.9
0 min (%)[a]	1.8	24.5	42.5	52.9	1.8	24.1
51-65 y (n = 3134)						
mean±SD	32.6±34.4	7.9±11.3	6.7±13.2	5.0±11.0	39.3±40.4	12.9±18.7
95% CI	31.4-33.8	7.5-8.3	6.2-7.1	4.6-5.4	37.9-40.7	12.2-13.5
0 min (%)[a]	6.3	25.6	53.9	56.6	6.3	25.4
All (n = 10 201)						
mean±SD	40.4±41.8	7.6±10.3	10.1±16.3	6.0±11.5	50.5±49.2	13.6±18.3
95% CI	39.5-41.2	7.4-7.8	9.8-10.4	5.8-6.2	49.5-51.4	13.2-13.9
0 min (%)[a]	2.9	23.7	40.3	52.0	2.9	23.4
Days off						
18-30 y (n = 940)						
mean±SD	71.0±67.3	9.4±13.5	19.0±26.7	8.6±16.2	90.0±79.5	18.0±25.2
95% CI	66.7-75.3	8.5-10.3	17.3-20.7	7.5-9.6	85.0-95.1	16.4-19.6
0 min (%)[a]	1.0	25.9	28.1	52.9	1.0	25.5
31-40 y (n = 2794)						
mean±SD	54.0±54.1	9.6±14.4	16.8±27.7	9.4±18.8	70.8±68.0	18.9±28.6
95% CI	51.9-56.0	9.1-10.1	15.8-17.9	8.7-10.0	68.3-73.3	17.9-20.0
0 min (%)[a]	2.0	28.4	35.2	54.5	2.0	28.2
41-50 y (n = 3333)						
mean±SD	47.4±46.6	10.5±15.0	14.3±24.4	9.3±18.9	61.6±57.1	19.8±28.3
95% CI	45.8-48.9	10.0-11.0	13.4-15.1	8.6-9.9	59.7-63.6	18.8-20.7
0 min (%)[a]	4.1	26.6	43.9	54.8	4.1	26.3
51-65 y (n = 3134)						
mean±SD	41.8±42.8	10.5±15.4	9.8±20.6	7.7±17.5	51.6±53.0	18.2±27.7
95% CI	40.3-43.3	10.0-11.1	9.1-10.5	7.0-8.3	49.8-53.5	17.2-19.2
0 min (%)[a]	6.6	29.2	55.9	58.5	6.5	28.8
All (n = 10 201)						
mean±SD	49.6±50.6	10.2±14.8	14.0±24.7	8.7±18.2	63.7±62.4	18.9±27.9
95% CI	48.7-50.6	9.9-10.4	13.6-14.5	8.4-9.1	62.5-64.9	18.3-19.4
0 min (%)[a]	4.0	27.8	43.7	55.7	4.0	27.6

[a]Percent of individuals with 0 minutes of the specific physical activity.
The difference between absolute and relative intensity physical activity was statistically significant for all age groups and physical activity intensities both during workdays and days off ($P < .001$, Wilcoxon signed rank test).
Except for MPA_{Rel} and $MVPA_{Rel}$ during days off, there was a statistically significant difference ($P < .001$, Kruskal-Wallis test) in the amount of physical activity between age groups.
Abbreviations: MPA_{Abs} = moderate physical activity, absolutely determined intensity: 3.0-<6.0 metabolic equivalents (METs); MPA_{Rel} = moderate physical activity, relatively determined intensity: 40-<60% oxygen uptake reserve (VO_2R); VPA_{Abs} = vigorous physical activity, absolutely determined intensity: ≥6.0 METs; VPA_{Rel} = vigorous physical activity, relatively determined intensity: ≥60% VO_2R; MVPA = moderate-to-vigorous physical activity combined.

TABLE 4. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups during workdays and days off among women.

	MPA_{Abs}	MPA_{Rel}	VPA_{Abs}	VPA_{Rel}	$MVPA_{Abs}$	$MVPA_{Rel}$
Workdays						
18-30 y (n = 1148)						
mean±SD	55.9±40.0	13.0±12.3	16.0±19.7	9.6±14.1	71.9±50.1	22.6±22.3
95% CI	53.6-58.2	12.3-13.7	14.9-17.1	8.8-10.5	69.0-74.8	21.3-23.9
0 min (%)[a]	0.4	7.8	21.1	31.9	0.4	7.5
31-40 y (n = 3087)						
mean±SD	34.6±31.0	9.8±10.4	8.1±13.4	6.7±11.2	42.7±38.1	16.4±18.0
95% CI	33.5-35.7	9.4-10.2	7.6-8.5	6.3-7.1	41.3-44.0	15.8-17.1
0 min (%)[a]	2.3	11.9	42.0	39.1	2.3	11.7
41-50 y (n = 4512)						
mean±SD	24.4±23.7	9.3±10.0	4.4±9.9	5.9±10.5	28.8±28.3	15.2±17.5
95% CI	23.7-25.1	9.0-9.6	4.1-4.7	5.6-6.3	27.9-29.6	14.7-15.7
0 min (%)[a]	5.6	12.9	64.1	42.0	5.6	12.7
51-65 y (n = 4276)						
mean±SD	19.0±21.2	10.5±12.4	1.6±6.3	6.2±13.9	20.6±23.7	16.8±23.3
95% CI	18.4-19.6	10.2-10.9	1.4-1.8	5.8-6.6	19.9-21.3	16.1-17.5
0 min (%)[a]	12.9	13.8	83.6	43.0	12.9	13.6
All (n = 13 023)						
mean±SD	27.8±28.6	10.1±11.2	5.4±11.8	6.5±12.2	33.2±35.2	16.7±20.2
95% CI	27.3-28.3	10.0-10.3	5.2-5.6	6.3-6.7	32.6-33.8	16.3-17.0
0 min (%)[a]	6.7	12.5	61.5	40.8	6.7	12.3
Days off						
18-30 y (n = 1148)						
mean±SD	54.2±46.3	12.0±13.9	15.2±21.4	9.3±15.1	69.4±57.9	21.3±24.6
95% CI	51.6-56.9	11.2-12.8	13.9-16.4	8.4-10.2	66.0-72.7	19.8-22.7
0 min (%)[a]	1.8	17.2	33.3	42.5	1.8	17.0
31-40 y (n = 3087)						
mean±SD	33.5±33.6	9.2±11.7	8.7±16.2	7.3±13.7	42.3±41.7	16.6±21.2
95% CI	32.3-34.7	8.8-9.6	8.2-9.3	6.9-7.8	40.8-43.7	15.8-17.3
0 min (%)[a]	6.9	24.6	52.5	52.0	6.9	24.2
41-50 y (n = 4512)						
mean±SD	26.0±28.6	9.8±12.7	5.8±14.4	7.6±15.3	31.8±35.3	17.3±23.3
95% CI	25.2-26.9	9.4-10.1	5.4-6.2	7.1-8.0	30.8-32.9	16.7-18.0
0 min (%)[a]	11.6	23.8	69.3	52.7	11.6	23.5
51-65 y (n = 4276)						
mean±SD	20.6±27.2	10.9±14.8	2.4±9.8	7.4±17.0	23.0±31.5	18.3±27.3
95% CI	19.8-21.5	10.5-11.4	2.1-2.7	6.9-7.9	22.1-23.9	17.5-19.1
0 min (%)[a]	21.7	24.4	85.7	53.7	21.7	24.0
All (n = 13 023)						
mean±SD	28.5±32.7	10.2±13.3	6.2±14.8	7.6±15.5	34.7±40.4	17.8±24.4
95% CI	28.0-29.1	10.0-10.4	5.9-6.5	7.3-7.9	34.0-35.4	17.4-18.2
0 min (%)[a]	13.0	23.6	67.5	52.0	13.0	23.3

[a]Percent of individuals with 0 minutes of the specific physical activity.
Except for VPA_{Abs} *vs*. VPA_{Rel} during days off in the group aged 41-50 years, there was a statistically significant difference between absolute and relative intensity physical activity (P < .001, Wilcoxon signed rank test) in all age groups and intensity categories.
There was a statistically significant difference (P < .001, Kruskal-Wallis test) in all intensity categories between age groups.
Abbreviations: MPA_{Abs} = moderate physical activity, absolutely determined intensity: 3.0-<6.0 metabolic equivalents (METs); MPA_{Rel} = moderate physical activity, relatively determined intensity: 40-<60% oxygen uptake reserve (VO_2R); VPA_{Abs} = vigorous physical activity, absolutely determined intensity: ≥6.0 METs; VPA_{Rel} = vigorous physical activity, relatively determined intensity: ≥60% VO_2R; MVPA = moderate-to-vigorous physical activity combined.

TABLE 5. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by weight status during workdays and days off among men.

	MPA_{Abs}	MPA_{Rel}	VPA_{Abs}	VPA_{Rel}	$MVPA_{Abs}$	$MVPA_{Rel}$
Workdays						
Normal weight (n = 3655)						
mean±SD	46.6±47.7	8.0±10.1	13.3±17.7	7.0±11.8	59.9±55.0	15.0±18.4
95% CI	45.1-48.2	7.7-8.3	12.7-13.9	6.6-7.3	58.1-61.7	14.4-15.6
0 min (%)[a]	1.2	21.3	28.1	46.5	1.2	20.9
Overweight (n = 5024)						
mean±SD	38.2±38.1	7.3±10.3	9.5±16.2	6.0±11.7	47.8±45.7	13.3±18.6
95% CI	37.2-39.3	7.0-7.6	9.1-10.0	5.7-6.4	46.5-49.1	12.8-13.8
0 min (%)[a]	2.6	24.2	42.7	53.1	2.6	24.0
Obese (n = 1522)						
mean±SD	32.2±36.2	7.4±10.6	4.5±10.6	3.8±9.2	36.7±40.5	11.2±16.5
95% CI	30.4-34.0	6.9-8.0	4.0-5.0	3.3-4.2	34.7-38.8	10.4-12.0
0 min (%)[a]	7.7	27.5	61.8	61.6	7.7	27.5
All (n = 10 201)						
mean±SD	40.4±41.8	7.6±10.3	10.1±16.3	6.0±11.5	50.5±49.2	13.6±18.3
95% CI	39.5-41.2	7.4-7.8	9.8-10.4	5.8-6.2	49.5-51.4	13.2-13.9
0 min (%)[a]	2.9	23.7	40.3	52.0	2.9	23.4
Days off						
Normal weight (n = 3655)						
mean±SD	56.6±55.4	10.5±15.0	18.8±28.2	10.6±20.0	75.4±68.0	21.1±29.4
95% CI	54.8-58.4	10.0-11.0	17.8-19.7	10.0-11.3	73.1-77.6	20.1-22.1
0 min (%)[a]	2.2	26.6	33.3	51.5	2.1	26.3
Overweight (n = 5024)						
mean±SD	47.7±47.7	9.9±14.6	12.5±23.0	8.0±17.1	60.2±58.8	17.9±27.0
95% CI	46.4-49.0	9.5-10.3	11.9-13.2	7.5-8.5	58.6-61.9	17.1-18.6
0 min (%)[a]	4.0	28.3	45.3	56.6	4.0	28.0
Obese (n = 1522)						
mean±SD	39.4±45.0	10.2±15.1	7.7±18.3	6.6±16.7	47.0±54.7	16.9±27.0
95% CI	37.1-41.6	9.5-11.0	6.7-8.6	4.8-7.5	44.3-49.8	15.5-18.2
0 min (%)[a]	8.6	29.2	63.8	62.8	8.6	29.1
All (n = 10 201)						
mean±SD	49.6±50.6	10.2±14.8	14.0±24.7	8.7±18.2	63.7±62.4	18.9±27.9
95% CI	48.7-50.6	9.9-10.4	13.6-14.5	8.4-9.1	62.5-64.9	18.3-19.4
0 min (%)[a]	4.0	27.8	43.7	55.7	4.0	27.6

[a]Percent of individuals with 0 minutes of the specific physical activity.

Except for VPA_{Abs} *vs*. VPA_{Rel} during days off in obese weight status group, there was a statistically significant difference between absolute and relative intensity physical activity (P < .001, Wilcoxon signed rank test) in all weight status groups and intensity categories.

Except for MPA_{Rel}, there was a statistically significant difference (P < .001, Kruskal-Wallis test) in all activity types between weight status groups.

Abbreviations: MPA_{Abs} = moderate physical activity, absolutely determined intensity: 3.0-<6.0 metabolic equivalents (METs); MPA_{Rel} = moderate physical activity, relatively determined intensity: 40-<60% oxygen uptake reserve (VO_2R); VPA_{Abs} = vigorous physical activity, absolutely determined intensity: ≥6.0 METs; VPA_{Rel} = vigorous physical activity, relatively determined intensity: ≥60% VO_2R; MVPA = moderate-to-vigorous physical activity combined.

Normal weight = body mass index 18.5-<25.0 kg/m^2.

Overweight = body mass index 25.0-<30.0 kg/m^2.

Obese = body mass index 30.0-40.0 kg/m^2.

TABLE 6. Amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by weight status during workdays and days off among women.

	MPA_{Abs}	**MPA_{Rel}**	**VPA_{Abs}**	**VPA_{Rel}**	**$MVPA_{Abs}$**	**$MVPA_{Rel}$**
Workdays						
Normal weight (n = 7073)						
mean±SD	34.8±30.9	10.3±10.5	8.4±14.2	7.3±11.9	43.1±38.5	17.6±18.9
95% CI	34.1-35.5	10.0-10.5	8.0-8.7	7.1-7.6	42.4-44.0	17.2-18.1
0 min (%)[a]	3.0	11.3	44.1	37.6	3.0	11.1
Overweight (n = 3847)						
mean±SD	22.4±24.8	9.0±10.2	2.5±7.7	4.7±9.2	24.9±28.6	14.0±16.7
95% CI	21.6-23.2	8.7-9.4	2.3-2.7	4.4-4.9	24.0-25.8	13.2-14.2
0 min (%)[a]	8.8	15.2	76.0	46.4	8.8	14.9
Obese (n = 2103)						
mean±SD	14.3±18.5	11.7±14.6	0.6±3.6	7.2±16.8	14.9±19.7	18.9±28.4
95% CI	13.5-15.1	11.1-12.3	0.4-0.7	6.5-7.9	14.0-15.7	17.7-20.1
0 min (%)[a]	15.7	11.7	93.2	41.0	15.7	11.4
All (n = 13 023)						
mean±SD	27.8±28.6	10.1±11.2	5.4±11.8	6.5±12.2	33.2±35.2	16.7±20.2
95% CI	27.3-28.3	10.0-10.3	5.2-5.6	6.3-6.7	32.6-33.8	16.3-17.0
0 min (%)[a]	6.7	12.5	61.5	40.8	6.7	12.3
Days off						
Normal weight (n = 7073)						
mean±SD	35.8±36.0	10.4±13.2	9.8±18.1	9.0±16.2	45.6±45.2	19.4±24.4
95% CI	35.0-36.7	10.1-10.7	9.4-10.2	8.6-9.4	44.6-46.7	18.9-20.0
0 min (%)[a]	6.4	21.9	52.7	48.7	6.4	21.5
Overweight (n = 3847)						
mean±SD	23.1±27.5	9.4±12.3	2.6±8.7	5.4±12.1	25.8±31.3	14.8±20.6
95% CI	22.3-24.0	9.0-9.8	2.4-2.9	5.0-5.8	24.8-26.8	14.1-15.4
0 min (%)[a]	16.9	26.3	79.7	56.6	16.9	26.1
Obese (n = 2103)						
mean±SD	13.8±20.7	10.9±15.4	0.6±4.41	7.0±18.1	14.4±22.3	17.9±29.5
95% CI	12.9-14.7	10.2-11.6	0.4-0.8	6.3-7.8	13.4-15.3	16.7-19.2
0 min (%)[a]	27.7	24.5	95.2	54.2	27.7	24.1
All (n = 13 023)						
mean±SD	28.5±32.7	10.2±13.3	6.2±14.8	7.6±15.5	34.7±40.4	17.8±24.4
95% CI	28.0-29.1	10.0-10.4	5.9-6.5	7.3-7.9	34.0-35.4	17.4-18.2
0 min (%)[a]	13.0	23.6	67.5	52.0	13.0	23.3

[a]Percent of individuals with 0 minutes of the specific physical activity.
There was a statistically significant difference between absolute and relative intensity physical activity (P < .001, Wilcoxon signed rank test) in all weight status groups and intensity categories.
There was a statistically significant difference (P < .001, Kruskal-Wallis test) in all activity types between weight status groups.
Abbreviations: MPA_{Abs} = moderate physical activity, absolutely determined intensity: 3.0-<6.0 metabolic equivalents (METs); MPA_{Rel} = moderate physical activity, relatively determined intensity: 40-<60% oxygen uptake reserve (VO_2R); VPA_{Abs} = vigorous physical activity, absolutely determined intensity: ≥6.0 METs; VPA_{Rel} = vigorous physical activity, relatively determined intensity: ≥60% VO_2R; MVPA = moderate-to-vigorous physical activity combined.
Normal weight = body mass index 18.5-<25.0 kg/m^2.
Overweight = body mass index 25.0-<30.0 kg/m^2.
Obese = body mass index 30.0-40.0 kg/m^2.

Supplemental Digital Content 2

Kujala UM, Pietilä J, Myllymäki T, et al. Physical Activity: Absolute Intensity vs. Relative-to-Fitness-Level Volumes

All results in Supplemental Digital Content 2 are based on calculating resting metabolic rate individually using the Harris-Benedict formula.

TABLE 1. Mean estimated resting metabolic rates (VO_2 values) by sex, age and weight groups according to Harris-Benedict formula.

TABLE 2. The mean daily amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups and by weight status among men and women.

FIGURE 1. Overlap (mean percent of PA minutes falling in different intensity categories) between absolute PA intensity *vs.* PA intensity relative to individual aerobic fitness level.

This supplementary material has been provided by the authors to give readers additional information about their work.

TABLE 1. Mean estimated resting metabolic rates (VO_2 values) by sex, age and weight groups according to Harris-Benedict formula.

	Men	Women
	Mean±SD	
Resting metabolic rate by age groups		
18-30 y	3.3±0.2	3.2±0.3
31-40 y	3.1±0.2	3.0±0.3
41-50 y	3.0±0.1	2.8±0.3
51-65 y	2.9±0.1	2.7±0.2
Resting metabolic rate by weigh groups		
Normal	3.2±0.2	3.0±0.2
Overweight	3.0±0.1	2.7±0.1
Obese	2.8±0.1	2.5±0.1

Normal = body mass index 18.5-<25.0 kg/m^2
Overweight = body mass index 25.0-<30.0 kg/m^2
Obese = body mass index 30.0-40.0 kg/m^2

TABLE 2. The Mean[a] daily amount of absolute and relative moderate and vigorous intensity physical activity (min/day) by age groups and by weight status among men and women.

	MPA_{Abs}	MPA_{Rel}	VPA_{Abs}	VPA_{Rel}	$MVPA_{Abs}$	$MVPA_{Rel}$
			Mean (95% CI) minutes			
Activity volumes by age groups						
Men						
18-30 y	87.7 (84.2-91.2)	9.2 (8.7-9.8)	20.3 (19.2-21.5)	7.9 (7.2-8.5)	108.0 (104.0-112.0)	17.1 (16.1-18.1)
31-40 y	72.2 (70.4-74.0)	8.6 (8.3-9.0)	17.7 (17.0-18.4)	8.1 (7.7-8.6)	89.9 (87.8-92.0)	16.8 (16.1-17.4)
41-50 y	70.2 (68.6-71.7)	9.3 (9.0-9.6)	16.1 (15.6-16.7)	7.9 (7.5-8.3)	86.3 (84.6-88.1)	17.2 (16.6-17.8)
51-65 y	67.7 (66.2-69.2)	9.9 (9.6-10.3)	13.3 (12.7-13.8)	6.6 (6.2-7.0)	81.0 (79.2-82.7)	16.5 (15.9-17.1)
Women						
18-30 y	74.1 (71.8-76.4)	12.9 (12.3-13.4)	19.4 (18.5-20.4)	9.7 (9.1-10.3)	93.5 (90.8-96.2)	22.5 (21.6-23.5)
31-40 y	52.9 (51.8-54.0)	10.1 (9.8-10.4)	12.1 (11.7-12.5)	7.2 (6.9-7.6)	65.0 (63.7-66.3)	17.3 (16.8-17.8)
41-50 y	43.8 (43.0-44.5)	10.6 (10.4-10.9)	9.3 (9.0 9.6)	7.2 (6.9-7.4)	53.1 (52.1-54.0)	17.8 (17.4-18.3)
51-65 y	37.5 (36.8-38.3)	13.4 (13.0-13.9)	5.5 (5.3-5.8)	7.6 (7.3-8.0)	43.1 (46.2-44.0)	21.1 (20.4-21.8)
Activity volumes by weight status						
Men						
Normal	68.6 (67.1-70.1)	9.5 (9.2-9.8)	18.9 (18.3-19.5)	8.9 (8.5-9.3)	87.5 (85.8-89.2)	18.4 (17.8-18.9)
Overweight	72.4 (71.1-73.7)	9.0 (8.8-9.3)	15.4 (14.9-15.9)	7.2 (6.9-7.5)	87.8 (86.3-89.3)	16.2 (15.8-16.7)
Obese	76.1 (73.5-78.6)	9.8 (9.3-10.3)	11.5 (10.8-12.3)	5.5 (5.0-6.0)	87.6 (84.6-90.5)	15.3 (14.4-16.1)
Women						
Normal	49.7 (49.0-50.4)	10.9 (10.7-11.1)	12.7 (12.4-13.0)	8.4 (8.2-8.6)	62.5 (61.6-63.3)	19.3 (18.9-19.7)
Overweight	43.7 (42.8-44.6)	10.5 (10.2-10.7)	7.0 (6.7-7.3)	5.4 (5.2-5.7)	50.7 (49.7-51.8)	15.9 (15.5-16.4)
Obese	41.0 (39.8 42.3)	16.3 (15.5-17.0)	4.0 (3.7-4.3)	8.6 (7.9-9.2)	45.0 (43.6-46.4)	24.8 (23.6-26.1)
All men	71.6 (70.7-72.5)	9.3 (9.1-9.5)	16.1 (15.7-16.4)	7.6 (7.3-7.8)	87.7 (86.6-88.7)	16.9 (16.5-17.2)
All women	46.6 (46.0-47.1)	11.6 (11.4-11.8)	9.6 (9.4-9.8)	7.6 (7.4-7.7)	56.2 (55.6-56.8)	19.2 (18.9-19.5)

[a]Mean of all monitored work days and days off.

There was a statistically significant difference between absolute and relative intensity physical activity (*P*<.001, Wilcoxon signed rank test) in all age groups and weight status groups and intensity categories.

Except for MPA_{Rel} and $MVPA_{Rel}$ in men, there was a statistically significant difference (*P*<.001, Kruskal-Wallis test) in all intensity categories between age groups.

Except for MPA_{Rel} in men, there was a statistically significant difference (*P*<.001, Kruskal-Wallis test) in all activity types between weight status groups.

Abbreviations: MPA_{Abs} = moderate physical activity, absolutely determined intensity: 3.0-<6.0 metabolic equivalents (METs); MPA_{Rel} = moderate physical activity, relatively determined intensity: 40-<60 % oxygen uptake reserve (VO_2R)
VPA_{Abs} = vigorous physical activity, absolutely determined intensity: ≥6.0 METs; VPA_{Rel} = vigorous physical activity, relatively determined intensity: ≥60 % VO_2R
MVPA=moderate-to-vigorous physical activity combined, respectively
Normal = body mass index 18.5-<25.0 kg/m^2
Overweight = body mass index 25.0-<30.0 kg/m^2
Obese = body mass index 30.0-40.0 kg/m^2

FIGURE 1.

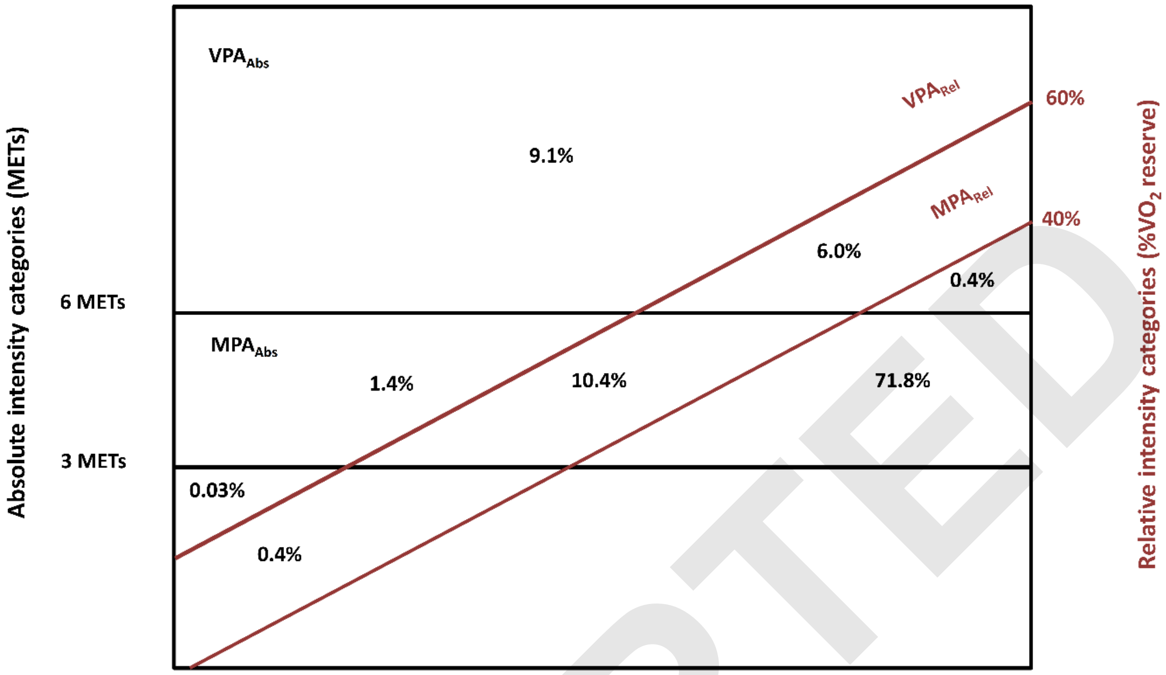


FIGURE 1. Overlap (mean percent of PA minutes falling in different intensity categories) between absolute PA intensity *vs.* PA intensity relative to individual aerobic fitness level.
Resting metabolic rate calculated individually using the Harris-Benedict formula.
Abbreviations: PA = physical activity; MET = multiples of the resting metabolic rate; $\%VO_2$ reserve = percentage of maximal oxygen uptake reserve.