Relationship Between Domain-Specific Physical Activity and Different Body Composition Measures in a Working Population

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Objective: With respect to the overweight epidemic, this study aimed to investigate the association between domain-specific physical activity and body composition measures in Swiss male employees. **Methods:** A total of 192 healthy male adults in full-time employment were investigated. Height, weight, and waist circumference were measured and body mass index was calculated. Relative fat mass and relative muscle mass were determined by bioelectric impedance analysis. Physical activity was assessed by the validated International Physical Activity Questionnaire. **Results:** In multiple linear regressions, leisure-time activity showed an inverse association with waist circumference and relative fat mass and a positive correlation with relative muscle mass. Work activity was positively related to waist circumference and body mass index. **Conclusions:** This study shows that leisure-time activity may be the most effective physical activity domain for body composition. Work activity does not seem to be protective against overweight.

Overweight and obesity, defined as abnormal and excessive fat accumulation, represent a major risk factor for several chronic diseases including type 2 diabetes, cardiovascular disease, hypertension and stroke, certain forms of cancer (breast, colon), and musculoskeletal disorders (osteoarthritis).[1,2] In turn, these comorbidities lead to an increased risk of premature death and reduced quality of life.[3] With at least 2.8 million adults dying each year as a result of being overweight or obese, this health burden globally represents the fifth leading cause of death.[2]

Worldwide obesity has nearly doubled since 1980 and has reached epidemic proportions.[2] In 2008, 1.4 billion (35%) overweight adults (body mass index [BMI] $\geq$25.0 kg/m^2) were registered, whereas 11% were obese (BMI $\geq$30.0 kg/m^2).[2] Regarding the situation in Switzerland, a similar development could be noticed. Between 1992 and 2012, the percentage of overweight individuals increased from 30% to 41%, whereas the percentage of obese people almost doubled (5.5% to 10%).[4] In 2012, men were 1.5 times more likely to be overweight than women (51% compared with 32%).[4]

The development of overweight and obesity can be explained by an increased intake of energy-dense high-fat food and a decrease in physical activity because of increasing sedentary behaviors resulting from technological and social changes.[2] Nevertheless, divergent trends in obesity prevalence (increasing) and fat intake (decreasing) detected in the US adult population and Great Britain between 1970 and 1990,[5,6] suggested that physical activity is the major predictor of obesity.[7] Concerning activity behavior in Switzerland, self-reported data from the latest Swiss Health Survey 2012 showed that 28% of adults were either insufficiently active or entirely inactive, when measured against the minimum recommendation of 150 minutes or more of moderate-intensity or 75 minutes or more of vigorous-intensity physical activity per week.[4] Physically, sufficiently active people were often less obese than inactive people (9% compared with 16%).[4] Although in epidemiological studies, measurements of physical activity are largely restricted to leisure-time pursuits,[8] the World Health Organization encourages practicing daily activities from different domains (occupational, leisure-time, transport, and domestic activities) to fulfill global recommendations on physical activity.[9] Bauman et al[10] confirmed the difficulty of achieving the required amount of physical activity for obesity prevention only through leisure-time activity alone. Considering the fact that most people in full-time employment spend about one third of the day at work, occupational physical activity may contribute to a large extent to total daily activity.[11] Furthermore, in middle-aged and elderly individuals, domestic activities represent a considerable proportion of total physical activity.[12]

Previous studies measuring the impact of physical activity on body composition are inconsistent. Although most investigations focused on leisure-time activity[8] and BMI-defined obesity,[13–16] there is evidence of also considering other domains of physical activity and further body composition measures. Because BMI may be biased in subjects with a large muscle mass (MM),[2] relative fat mass (FM) and relative MM should also be investigated. Waist circumference (WC) as well should be considered, as it was found to be more closely linked to health outcomes than BMI.[17,18] The association between the different physical activity domains (occupational, leisure-time, transport, and domestic activity) and the body composition measures (WC, relative FM, relative MM, and not just BMI alone) has not been sufficiently investigated.

The primary aim of this study was therefore to assess whether occupational, leisure-time, transport, and domestic physical activity were independently associated with BMI, WC, relative FM, and relative MM in a Swiss male working population. These analyses focused on male adults because of the high overweight prevalence in this population group.

METHODS

Study Subjects

From June 2010 to May 2011, 192 healthy male adults in full-time employment were recruited at the Blood Donation Centre of the University Hospital of Basel, Switzerland. Exclusion criteria were unpaid occupation, insufficient knowledge of the German language, and accidents within the last 3 months, because accidents would have prevented usual physical activity behavior and altered body composition. This investigation was approved by the local

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ethics committee (EKBB, 37/09) and written informed consent was obtained from all subjects.

Study Design and Procedures

In this cross-sectional study, body measurements were performed before the blood donation process. The measurements were always carried out by the same study nurses trained for this purpose. First, height, weight, and WC were measured once for each participant and BMI was calculated. Then, a phase-sensitive bioelectric impedance analysis (BIA) was performed, providing results of relative FM and relative MM. The long version of the International Physical Activity Questionnaire (IPAQ) was administered to the participants to assess past week work and non–work-related physical activity. In addition, several personal and job-related factors were recorded as part of a separate generic questionnaire. Subjects could complete the questionnaires immediately or send them back within the next few days by a post-paid envelope.

Body Composition Measurement

For a detailed determination of body composition, anthropometric measurements and a four-point ipsilateral phase-sensitive BIA were performed. Height was assessed without shoes by a medical measuring stick (model Seca 217, measurement range: 20 to 205 cm, seca ag, Reinach, Switzerland) to the nearest mm. The measurement of weight was performed on subjects in light clothing without shoes by a medical scale (model Seca 877, load capacity: 200 kg, seca ag, Reinach, Switzerland) with an accuracy of 0.1 kg. Body mass index was calculated from measured height and weight (BMI $=$ weight/height^2 [kg/m^2]). Subjects with a BMI of 25.0 kg/m^2 or more were classified as overweight, and those with a BMI of 30.0 kg/m^2 or more as obese.[2] Waist circumference was determined midway between the lowest rib and the iliac crest according to the Swiss Heart Foundation using a medical measuring tape (model Seca 201, maximum length: 205 cm) with a precision of 0.1 cm. The measurement was carried out on standing subjects after a moderate expiration. A value of more than 102 cm was defined as high-risk WC.[19] Furthermore, resistance and reactance were measured by a medically classified BIA device (Akern BIA 101, SMT Medical GmbH&Co, Würzburg, Germany) to the nearest ohm. This method, determining specific conductivities of different tissue types, is characterized by a high reliability and validity.[20] Relative FM (%) and relative MM (%) were computed by the software Akern BodyGramPro (version 1.21, SMT Medical GmbH&Co, Würzburg, Germany) using the measured values of resistance and reactance. Age, sex, height, and weight were also considered in these calculations. A value of more than 25% was defined as high-risk relative FM.[21] In three cases, relative FM and relative MM were not computed because BIA was not performed in these subjects. They were therefore excluded from the corresponding analyses.

Physical Activity Assessment

The IPAQ was used to assess work and non–work-related physical activity because it is a simple instrument for measuring health-enhancing physical activity at the population level.[22] Validity and reliability were established in 12 different countries.[22] The German long version of the IPAQ designed for adults aged 15 to 69 years was administered to the participants. It consists of 26 questions and assesses past week frequency and duration of physical activity within the domains of work, leisure-time, transport, and domestic activity. Continuous scores in the form of metabolic equivalent (MET)·minutes per week were calculated for each domain and for moderate and vigorous activity according to the IPAQ guidelines for data analysis.[23] Total physical activity was calculated by adding up subtotal domain-specific scores. One MET defined as metabolic equivalent and expressing the energy cost of physical activity corresponds to 3.5 mL/min/kg of VO_2.[24] MET·minutes per week were computed by multiplying the intensity (MET value) of an activity with its frequency (days per week) and duration (minutes per day). The MET values are set by the IPAQ guidelines on the basis of the compendium of physical activity.[25] Leisure-time, work, and total physical activity were classified into categories of insufficiently ($<$600 MET·min/wk) and sufficiently active people ($\geq$600 MET·min/wk) according to current guidelines.[9]

Personal and Job-Related Factors

Age (18 to 34/35 to 49/50 to 65 years), nationality (Swiss/no Swiss), marital status (single/married/divorced), smoking status (no/yes), alcohol consumption (never/once to several times per month/once per week/several times per week/once to several times per day), medication (no/yes), highest education (compulsory school/apprenticeship/higher vocational school/diploma or maturity/university), and current profession were recorded by asking the participants. The reported occupations were classified (nine categories) according to the International Standard Classification of Occupations (ISCO-88).[26] These categories were combined (three groups) on the basis of self-reported IPAQ work activity (executives, scientists/technicians, clerks, salespersons, machine operators/craftsmen, agricultural workers, laborers). Furthermore, the season of recruitment (spring/summer/autumn/winter) was also documented because physical activity behavior might differ across seasons.

Statistical Analyses

The primary endpoints were BMI, WC, relative FM, relative MM, and physical activity levels in the domains of work, leisure-time, transport, and domestic activity. Data were analyzed using the SPSS software package (version 19.0, IBM, Germany). Significance was set at the 5% level. The Shapiro-Wilk test was used to test whether data were normally distributed. Subjects' characteristics are presented as mean (standard deviation), median (interquartile range) or number (percentage). Nationality, smoking status and medication were analyzed as binary variables. For all other factors with more than two categories, dummy variables were created. Mean comparisons were performed using independent *t* test or one-way analysis of variance in case of parametric data, whereas Mann-Whitney test or Kruskal-Wallis test was applied for nonparametric data. Furthermore, Pearson or Spearman correlations were calculated depending on data distribution. To assess the independent association of different physical activity domains with body composition, backward stepwise multiple linear regression analyses were conducted for each outcome variable (BMI, WC, relative FM, and relative MM). Work, leisure-time, transport, and domestic activity were considered as predictors, and all analyses were adjusted for significant confounders (age, marital status, medication, and season of recruitment). The models were checked for multicollinearity of predictors. Therefore, total physical activity was not considered in the analyses because of its high collinearity with work activity ($r = 0.80$; $P < 0.001$).[27]

RESULTS

Participants' Characteristics

Subjects' characteristics are presented in Table 1. Age ranged from 18 to 62 years, with a mean age of 41.6 ± 11 years. A total of 137 individuals (71.4%) were found to be overweight (BMI $\geq$25.0 kg/m^2), whereas 37 (19.3%) were obese (BMI $\geq$30.0 kg/m^2). A total of 57 subjects (29.7%) had a high-risk WC ($>$102 cm) and 46 subjects (24.3%) had a high-risk relative FM ($>$25%). Participants were predominantly Swiss ($n = 178$; 92.7%), married, and nonsmoker ($n = 155$; 80.7%). In addition, the majority did not take any medicine, and alcohol consumption was most frequent between one to several times per week ($n = 120$; 62.5%). Two thirds had completed an apprenticeship, whereas almost half of the participants were craftsmen. Most subjects were recruited in autumn and winter. Regarding

TABLE 1. Characteristics of the 192 Male Study Participants

Variables	Mean (SD)
Age, yrs	41.6 (11.0)
Height, m	1.77 (0.07)
Weight, kg	85.0 (13.6)
BMI, kg/m^2	27.0 (3.8)
WC, cm	96.9 (11.7)
Relative FM, %	21.0 (6.1)
Relative MM, %	53.8 (5.1)
	Median (IQR)
Total PA, MET·min/wk	3518 (2202–7295)
Work PA, MET·min/wk	1139 (126–4555)
Leisure-time PA, MET·min/wk	638 (198–1493)
Domestic PA, MET·min/wk	445 (120–1080)
Transport PA, MET·min/wk	330 (66–792)
Moderate PA, MET·min/wk	1868 (840–4280)
Vigorous PA, MET·min/wk	960 (120–2520)

BMI, body mass index; FM, fat mass; IQR, interquartile range; MET, metabolic equivalent; MM, muscle mass; PA, physical activity; SD, standard deviation; WC, waist circumference.

participation in different physical activity domains (Table 1), work activity contributed to 53.0% to total physical activity, followed by leisure-time activity (20.6%), domestic activity (16.0%), and transport activity (10.4%). Leisure-time activity compared with work activity consisted of more vigorous—median (interquartile range): 560 (0 to 6720) versus 80 (0 to 1440) MET·min/week—but less moderate activity—median (interquartile range): 0 (0 to 119) versus 400 (0 to 1781) MET·min/week—whereas transport and domestic activity included only moderate activities.[23]

Univariate analyses revealed that married persons and subjects taking medicine showed significantly higher values of BMI, WC, and relative FM as well as a lower value of relative MM than singles and those without current medication (Table 2). In contrast, no significant differences in body composition were found between categories of highest education, profession, nationality, smoking status, and alcohol consumption (see Table, Supplemental Digital Content 1, for more details). Regarding seasonal differences, participants recruited in autumn had a significant higher WC and relative FM as well as a lower relative MM than those recruited in spring and winter. No significant differences were detected between summer and autumn. When classifying subjects into physical activity categories (Table 3), WC and relative FM were reduced and relative MM was increased in people meeting the minimum recommendations for leisure-time and total physical activity. Regarding work activity, no significant differences were found. The proportion of subjects being sufficiently active increased from 51.6% (leisure-time activity) to 95.8% when including all four domains of physical activity.

Looking at physical activity levels across demographic characteristics and body composition measures (Table 4), obese persons had higher levels of total, work, domestic, and moderate activity than normal weight and overweight subjects. Similar findings were found for those with a high-risk WC and relative FM. Furthermore, craftsmen, laborers, and agricultural workers showed higher levels of total, work, moderate, and vigorous activity compared with other occupations. Leisure-time activity was increased in individuals with a normal WC and relative FM compared with peers with high-risk values. No significant differences were found for transport activity. Physical activity levels did not differ across ages.

Correlation of Physical Activity Domains With Body Composition

In Table 5, it is shown that leisure-time activity was related to all body parameters having the strongest association with relative FM and relative MM. In contrast, work activity showed a positive correlation with BMI, whereas domestic and transport activities were not found to correlate significantly with any of these parameters. In addition, age was found to be associated with BMI ($r = 0.19$; $P = 0.005$), WC ($r = 0.31$; $P < 0.001$), and relative MM ($r = -0.25$; $P < 0.001$). No significant relationship was detected between age and relative FM ($P = 0.130$).

Furthermore, work activity and domestic activity were observed to correlate significantly with each other ($r = 0.25$; $P < 0.001$), whereas leisure-time activity showed a significant association with transport activity ($r = 0.23$; $P = 0.001$). Furthermore, nonsignificant correlations between different physical activity domains are presented in Table of Supplemental Digital Content 2.

Independent Predictors of Body Composition

The multiple linear regression analyses with BMI, WC, relative FM, and relative MM as outcome variables are presented in Table 6. Leisure-time activity showed a significant association with relative FM, WC, and relative MM. No significant relationship was detected with BMI. Work activity was found to be positively related to BMI and WC. A weak correlation was observed between transport activity and relative FM, whereas domestic activity was not associated with any of these measures. Moreover, it was shown that age, medication, and season of recruitment correlated with body composition. Seasonal variations were found to be related to all parameters. Medication was associated with BMI, WC, and relative FM, but not with relative MM. Regarding age, a significant relationship was observed with WC and relative MM.

DISCUSSION

Generalizability of Results

The present findings are in accordance with a previous population-based study that has used the IPAQ-long version. Our results showed a median total physical activity of 3518 MET·min/week, which is comparable to that observed in 80% or more employed Swedish adults amounting to 3965 MET·min/week.[11] The lack of difference in physical activity across ages is surprising, but consistent with Caspersen et al,[28] who reported in a national US population that physical activity patterns generally eroded most in adolescence from ages 15 through 18 years, continued eroding in young adulthood (18 to 29 years), whereas middle adulthood (30 to 64 years) often revealed relatively stable patterns.

Concerning body composition, similar results were found in prior studies measuring height, weight, and WC objectively. A comparable mean BMI (26.7 ± 5.1 kg/m^2) to this study (27.0 ± 3.8 kg/m^2) was reported in an Australian survey for full-time workers.[29] Stamatakis et al.[8] detected an analogous mean BMI of 27.0 ± 4.7 kg/m^2 and a mean WC of 95.5 ± 12.5 cm in adult Scottish men close to our finding (96.9 ± 11.7 cm).

Independent Association of Physical Activity Domains With Body Composition

This cross-sectional investigation conducted in a sample of Swiss male adults revealed that leisure-time activity was associated with lower WC, lower relative FM, and higher relative MM, but not with BMI. In contrast to this, work activity was associated with higher BMI and higher WC. No association between body composition and transport and domestic activity was found.

As the analyses show, not all activity domains may have the same impact on body composition. This could be related to several factors influencing the amount of energy expended, such as intensity

TABLE 2. Body Parameters According to Selected Demographic Characteristics ($n = 192$)

Variables	N (%)	BMI, kg/m² Mean (SD)	WC, cm Mean (SD)	Rel. FM, % Mean (SD)	Rel. MM, % Mean (SD)
Marital status					
Single*	63 (32.8)	26.2 (4.4)	93.7 (14.2)	19.9 (7.1)	55.3 (5.8)
Married	110 (57.3)	27.4 (3.5)	98.7 (9.7)	21.9 (5.5)	52.8 (4.4)
Divorced	19 (9.9)	27.5 (3.5)	97.4 (11.4)	19.6 (5.4)	55.2 (5.1)
		$P = 0.023$†	**$P = 0.001$**	**$P = 0.023$**	**$P = 0.003$**
Medication					
No*	153 (79.7)	26.4 (3.4)	94.7 (10.5)	20.2 (5.7)	54.4 (4.9)
Yes	39 (20.3)	29.5 (4.7)	105.6 (12.0)	24.2 (6.4)	51.5 (5.1)
		$P < 0.001$	**$P < 0.001$**	**$P < 0.001$**	**$P = 0.001$**
Season					
Summer	18 (9.4)	26.9 (3.2)	98.4 (13.8)	21.0 (9.2)	52.8 (6.6)
Autumn*	59 (30.7)	27.9 (3.9)	101.0 (11.6)	23.2 (5.4)	51.3 (3.9)
Winter	74 (38.5)	26.7 (3.2)	94.9 (8.9)	20.4 (4.5)	54.9 (4.3)
Spring	41 (21.4)	26.3 (4.9)	94.0 (13.7)	19.0 (7.3)	56.0 (5.8)
		$P = 0.132$	**$P = 0.004$**	**$P = 0.007$**	**$P < 0.001$**
Highest education					
Compulsory school	13 (6.8)	26.7 (4.9)	95.8 (14.1)	21.4 (7.6)	54.2 (6.9)
Apprenticeship*	131 (68.2)	27.4 (4.0)	97.8 (11.8)	21.3 (6.0)	53.6 (4.9)
Diploma or maturity	5 (2.6)	24.8 (1.5)	89.4 (6.0)	18.5 (2.9)	53.8 (3.6)
Higher vocational school	30 (15.6)	26.6 (3.1)	96.4 (11.7)	20.2 (6.6)	54.7 (5.7)
University	13 (6.8)	25.0 (2.7)	92.8 (7.8)	21.2 (5.3)	53.8 (4.2)
		$P = 0.125$	$P = 0.266$	$P = 0.604$	$P = 0.851$
Occupation					
Low work activity*	17 (8.9)	25.4 (2.8)	92.3 (8.0)	19.4 (5.1)	54.7 (4.3)
Medium work activity	62 (32.3)	27.2 (3.0)	98.5 (10.4)	22.2 (5.9)	52.5 (4.9)
High work activity	113 (58.9)	27.2 (4.3)	96.7 (12.6)	20.6 (6.3)	54.4 (5.2)
		$P = 0.176$	$P = 0.100$	$P = 0.139$	$P = 0.058$

*Reference group.
†Significant P values are highlighted in bold.
BMI, body mass index; Rel. FM, relative fat mass; Rel. MM, relative muscle mass; SD, standard deviation; WC, waist circumference.

TABLE 3. Body Parameters According to Categories of Leisure-Time, Work, and Total Physical Activity ($n = 192$)*

Variables, MET·min/wk	N (%)	BMI, kg/m² Mean (SD)	WC, cm Mean (SD)	Rel. FM, % Mean (SD)	Rel. MM, % Mean (SD)
Leisure-time PA					
Insufficiently active <600	93 (48.4)	27.2 (3.8)	98.5 (11.4)	22.2 (5.8)	52.5 (4.8)
Sufficiently active ≥600	99 (51.6)	26.9 (3.9)	95.4 (11.7)	19.9 (6.2)	55.1 (5.1)
		$P = 0.219$	**$P = 0.033$**†	**$P = 0.006$**	**$P < 0.001$**
Work PA					
Insufficiently active <600	81 (42.2)	26.6 (3.1)	96.7 (9.1)	20.9 (5.0)	53.7 (4.4)
Sufficiently active ≥600	111 (57.8)	27.4 (4.3)	97.1 (13.3)	21.1 (6.8)	53.9 (5.6)
		$P = 0.073$	$P = 0.443$	$P = 0.393$	$P = 0.365$
Total PA					
Insufficiently active <600	8 (4.2)	28.0 (2.5)	102.9 (5.5)	23.7 (3.4)	50.9 (1.5)
Sufficiently active ≥600	184 (95.8)	27.0 (3.9)	96.7 (11.8)	20.9 (6.2)	54.0 (5.2)
		$P = 0.157$	**$P = 0.022$**	$P = 0.101$	**$P < 0.001$**

*Total physical activity includes leisure-time, transport, domestic, and work activity.
†Significant P values are highlighted in bold.
BMI, body mass index; MET, metabolic equivalent; PA, physical activity; Rel. FM, relative fat mass; Rel. MM, relative muscle mass; SD, standard deviation; WC, waist circumference.

TABLE 4. Total, Domain-Specific, Moderate, and Vigorous Physical Activity (MET·min/wk) According to Demographic Characteristics ($n = 192$)

Variables, MET·min/wk	N (%)	Total PA Median (IQR)	Work PA Median (IQR)	Leisure-Time PA Median (IQR)	Transport PA Median (IQR)	Domestic PA Median (IQR)	Moderate PA Median (IQR)	Vigorous PA Median (IQR)
Age, yrs								
18–34*	53 (27.6)	3,778 (2,355–6,606)	1,320 (445–2,880)	792 (198–1,828)	330 (99–972)	450 (106–1,110)	1,800 (840–3,360)	1,240 (480–2,240)
35–49	92 (47.9)	3,726 (2,140–7,721)	1,133 (93–5,245)	638 (240–1,406)	335 (53–792)	460 (158–990)	1,918 (740–4,942)	960 (40–2,880)
50–65	47 (24.5)	3,327 (2,084–7,313)	480 (66–5,196)	504 (198–1,356)	300 (55–753)	423 (1,080–1,840)	1,840 (870–4,600)	960 (0–1,920)
		$P = 0.962$	$P = 0.826$	$P = 0.563$	$P = 0.806$	$P = 0.988$	$P = 0.831$	$P = 0.491$
BMI, kg/m^2								
Normal <25*	55 (28.6)	3,359 (2,243–7,684)	852 (0–3,055)	697 (306–2,160)	297 (65–742)	510 (120–1,230)	1,770 (450–4,110)	1,280 (320–2,160)
Overweight 25–30	100 (52.1)	3,315 (1,927–6,554)	720 (65–3,430)	693 (198–1,443)	300 (58–776)	370 (90–889)	1,583 (761–3,528)	760 (0–2,040)
Obese ≥30	37 (19.3)	5,331 (3,428–11,115)	2,880 (960–9,120)	537 (66–1,189)	509 (99–870)	657 (380–1,230)	2,820 (1,500–5,084)	1,440 (160–4,800)
		$P = 0.015$†	**$P = 0.002$**	$P = 0.278$	$P = 0.607$	**$P = 0.042$**	**$P = 0.006$**	$P = 0.168$
WC, cm								
Normal ≤102*	135 (70.3)	3,390 (2,220–7,115)	840 (66–3,600)	770 (278–1,752)	330 (73–840)	425 (120–1,110)	1,800 (720–4,110)	960 (160–2,160)
High-risk >102	57 (29.7)	3,956 (2,084–7,443)	1,840 (240–6,661)	528 (66–996)	339 (40–756)	505 (150–960)	2,140 (1,060–5,040)	720 (80–3,840)
		$P = 0.217$	**$P = 0.018$**	**$P = 0.008$**	$P = 0.393$	$P = 0.458$	**$P = 0.048$**	$P = 0.409$
Rel. FM, %								
Normal ≤25*	143 (75.7)	3,428 (2,190–6,893)	960 (120–3,260)	697 (240–1,752)	297 (65–792)	420 (100–1,080)	1,800 (745–3,645)	960 (120–2,160)
High-risk >25	46 (24.3)	5,206 (2,700–11,115)	2,340 (240–7,836)	496 (66–944)	365 (66–870)	545 (255–1,230)	2,660 (1,335–5,153)	1,080 (160–4,800)
		$P = 0.041$	**$P = 0.005$**	**$P = 0.010$**	$P = 0.241$	$P = 0.067$	**$P = 0.005$**	$P = 0.148$
Occupation								
Executives	5 (2.6)	2,084 (1,592–2,337)	0 (0–66)	1,280 (960–1,440)	186 (149–591)	240 (90–360)	360 (180–600)	960 (360–1,280)
Scientists	12 (6.3)	2,627 (1,387–3,578)	0 (0–134)	1,278 (320–2,109)	630 (461–1,059)	155 (53–475)	935 (150–1,970)	840 (80–1,140)
Technicians	10 (5.2)	3,173 (1,992–4,275)	269 (0–1,794)	665 (495–1,794)	675 (297–1,260)	503 (255–1,230)	1,340 (1,000–2,150)	400 (0–1,440)
Clerks	12 (6.3)	2,641 (1,281–4,991)	256 (0–1,230)	569 (189–2,055)	198 (0–305)	123 (95–735)	790 (370–2,388)	980 (0–2,400)
Salespersons	14 (7.3)	2,156 (1,714–3,288)	199 (80–594)	705 (360–1,752)	367 (0–936)	355 (106–870)	940 (520–2,040)	680 (0–1,920)
Agricultural workers	14 (7.3)	8,552 (3,489–12,125)	6,528 (1,299–8,160)	335 (54–1,061)	302 (65–594)	321 (0–2,219)	5,037 (945–5,108)	3,060 (960–6,720)
Craftsmen*	86 (44.8)	4,996 (2,505–8,903)	2,143 (720–5,516)	528 (198–1,338)	330 (40–792)	545 (229–1,150)	2,150 (1,060–4,765)	1,160 (320–3,840)
Machine operators	26 (13.5)	3,644 (2,108–4,674)	248 (0–2,400)	653 (219–1,554)	371 (149–891)	533 (90–1,020)	1,643 (660–2,620)	420 (0–1,520)
Laborers	13 (6.8)	6,517 (3,347–11,407)	5,196 (1,680–6,312)	918 (297–1,998)	165 (0–384)	423 (193–960)	2,880 (1,945–5,028)	2,000 (480–5,640)
		$P < 0.001$	**$P < 0.001$**	$P = 0.574$	$P = 0.094$	$P = 0.357$	**$P = 0.002$**	**$P = 0.016$**

*Reference group.
†Significant *P* values are highlighted in bold.
BMI, body mass index; IQR, interquartile range; MET, metabolic equivalent; PA, physical activity; Rel. FM, relative fat mass; WC, waist circumference.

TABLE 5. Bivariate Correlations Between Different Physical Activity Domains and Body Parameters ($n = 192$)

	BMI, kg/m²		WC, cm		Rel. FM, %		Rel. MM, %	
Variables, MET·min/wk	***r***	***P***	***r***	***P***	***r***	***P***	***r***	***P***
Work PA	0.16	**0.014***	0.07	0.172	0.06	0.228	− 0.01	0.428
Leisure-time PA	− 0.15	**0.017**	− 0.24	**<0.001**	− 0.26	**<0.001**	0.30	**<0.001**
Domestic PA	0.07	0.158	0.08	0.133	0.07	0.178	− 0.08	0.147
Transport PA	0.03	0.367	0.03	0.356	0.07	0.178	− 0.06	0.214

*Significant *P* values are highlighted in bold.
BMI, body mass index; MET, metabolic equivalent; PA, physical activity; *r*, correlation coefficient; Rel. FM, relative fat mass; Rel. MM, relative muscle mass; WC, waist circumference.

and duration of physical activity. Bernstein et al[30] confirmed that the risk of overweight and obesity is inversely related to vigorous, but not to moderate activities. Because we found leisure-time activity to be of higher intensity than other activity domains, the present results seem to be plausible and are in agreement with existing knowledge about physical activity reducing WC and relative FM and increasing relative MM. Furthermore, leisure-time activity is characterized by the use of large muscle groups in a rhythmic and dynamic way, whereas for example domestic activities mainly involve smaller upper body muscles.[31] Another explanation refers to the planned and structured nature of leisure-time activity. Because individuals often engage in leisure-time activity to achieve a specific goal, such as to maintain health, improve fitness, build up muscles and sport targets, they may generally follow a health-conscious lifestyle.

Concerning transport activity, a significant correlation was found with leisure-time activity. Nevertheless, no independent influence on body composition could be detected. This finding is unexpected because transport activity is usually practiced voluntarily and regularly on a daily basis. Nevertheless, it may not be intensive enough to protect against overweight because it does not consist of any vigorous activities.[23] Being the least accomplished activity domain, duration might also be a limiting factor. Nevertheless, Wagner et al[32] and Littman et al[14] provided evidence for promoting walking and cycling to work with regard to overweight prevention.

In terms of domestic activity, the results of this study are in agreement with previous investigations not finding an association with body composition.[12,33] Similarly to transport activity, the lack of relationship could be explained by the insufficient intensity, as domestic activity assessed by the IPAQ only includes moderate activities.[23] In addition, domestic activities are more intermittent producing lower energy expenditure[25] and performed less consciously than leisure-time activity. Therefore, it might be possible that participants are not able to accurately recall routine activities such as domestic tasks.

Despite the lack of relationship, the inclusion of transport and domestic activity to leisure-time activity in daily life may still provide a substantial contribution to meeting physical activity guidelines for overweight prevention.

Interestingly, and contrary to expectation, this study found work activity to be associated with higher BMI and higher WC. Several reasons may explain this paradox. Although work activity is the most reported activity type and contributed to 53.0% to total physical activity, it was found to be less intensive than leisure-time activity. In addition, subjects may have problems to accurately recall work activity because of its high duration. For example, some participants reported moderate work activity of more than 8 hours per day. A Brazilian study using the IPAQ-long version confirmed that male and female adults reported unusually high activity levels in the domain of work.[34] Therefore, the relationship between work activity and body parameters might be biased in this study.

TABLE 6. Backward Stepwise Multiple Linear Regression Analyses With BMI, WC, Relative FM, and Relative MM as Outcome Variables ($n = 192$)*

	B	SE B	β	P
Outcome variable: BMI, kg/m²— model ($R = 0.40$; $R^2 = 0.16$)				
Constant	29.10	0.62		
Medication	3.01	0.64	0.32	<0.001
Work PA, MET·min/wk	0.00	0.00	0.21	0.002
Spring vs autumn	− 1.32	0.63	− 0.14	0.039
Outcome variable: WC, cm—model ($R = 0.51$; $R^2 = 0.26$)				
Constant	99.42	3.84		
Medication	8.30	1.94	0.29	<0.001
Spring vs autumn	− 5.84	1.99	− 0.21	0.004
Leisure-time PA, MET·min/wk	− 0.00	0.00	− 0.18	0.005
Age, yrs	0.17	0.07	0.16	0.014
Winter vs autumn	− 3.49	1.70	− 0.15	0.041
Work PA, MET·min/wk	0.00	0.00	0.14	0.033
Outcome variable: relative FM, %—model ($R = 0.42$; $R^2 = 0.18$)				
Constant	24.94	1.00		
Leisure-time PA, MET·min/wk	− 0.00	0.00	− 0.28	<0.001
Medication	3.49	1.02	0.23	0.001
Spring vs autumn	− 2.55	0.99	− 0.17	0.011
Transport PA, MET·min/wk	0.00	0.00	0.15	0.030
Outcome variable: relative MM, **%**—model ($R = 0.52$; $R^2 = 0.27$)				
Constant	55.22	1.41		
Spring vs autumn	4.04	0.87	0.33	<0.001
Leisure-time PA, MET·min/wk	0.00	0.00	0.29	<0.001
Winter vs autumn	2.93	0.73	0.28	<0.001
Age, yrs	− 0.10	0.03	− 0.21	0.001

*In every model work, leisure-time, transport, and domestic activity as well as age, marital status, medication, and season of recruitment were included as predictors.
B, regression coefficient; β, standardized beta coefficient; BMI, body mass index; FM, fat mass; MET, metabolic equivalent; MM, muscle mass; PA, physical activity; SE, standard error; WC, waist circumference.

It may also be possible that individuals with highly active occupations follow an unhealthy lifestyle, such as consuming energy-dense food to compensate work-related energy expenditure. This was confirmed by a previous study reporting significantly increased energy intake in Portuguese males with high energy-expending occupations compared with those with low energy-expending ones.[35] Another explanation refers to the positive correlation between work activity and domestic activity. It could be hypothesized that individuals with high occupational activity do housework in recreation rather than engaging in leisure-time activities. Our results indicated higher levels of domestic and lower levels of leisure-time activity in craftsmen compared with executives and scientists, without reaching statistical significance. Takao et al[36] could show that leisure-time activity was significantly lower in blue-collar workers compared with clerks. Similarly, subjects in lower-status occupations were found to be less likely to participate in vigorous leisure-time activity sufficient for cardiorespiratory fitness.[37] Regarding body composition, Kaleta et al[16] and Ball et al[38] did not detect a relationship between work activity and the risk of being obese. In contrast, King et al[15] and Steeves et al[39] found high occupational activity to be inversely associated with obesity. Nevertheless, in these studies, work activity was classified into low and high occupational activity on the basis of reported job categories, which does not allow a continuous analysis in the form of MET·minutes per week.

Different Body Composition Measures and Physical Activity

Regarding different body parameters, the present results are in agreement with Stamatakis et al[8] detecting an inverse association of sports and exercise with WC, but not with BMI. In fact, BMI might be confounded by MM, which increases with many sports activities. Changes in body composition (decrease in WC and relative FM, together with increase in relative MM) may therefore occur without changes in body weight and BMI. Thus, subjects with high levels of MM may seem overweight or obese when, in fact, they are not.[40] This may explain the high observed BMI-defined prevalence of overweight (71.4%), whereas the percentage of subjects with a high-risk WC (29.7%) and a high-risk relative FM (24.3%) was considerably lower. Furthermore, this is a possible explanation for the lack of relationship between leisure-time activity and BMI, whereas WC and relative FM were inversely associated with this activity domain. In contrast, Ball et al[38] found neither BMI nor relative FM to be related to leisure-time activity in men. Because they determined relative FM by skinfold measurement deriving results from only six body locations, BIA referring to the whole body might provide more accurate values.

Strengths and Limitations

Because various obesity-related studies used self-reported height and weight,[14,16] the strengths of this study were objective measurement of anthropometric data and further assessment of relative FM and relative MM. For a precise analysis, it was of great value to consider relative MM as a potential confounder of body weight and BMI. In addition, intensity, duration, and frequency were assessed for both occupational and nonoccupational activities by a validated questionnaire (IPAQ), providing continuous scores in the form of MET·minutes per week. The IPAQ is one of the most used questionnaires globally; it has been evaluated in many countries and translated into many languages.[22,41] Still, there are some concerns whether the questions are interpreted similarly by individuals from different countries and cultures.[42,43] A strength of the IPAQ is its ability to provide participation estimates for different domains of physical activity, which allow a comprehensive analysis of activity behavior.[22] Nevertheless, one of the challenges associated with the IPAQ is its assessment of both moderate and vigorous activities within each domain. There is evidence that subjects may find it difficult to differentiate between moderate and vigorous physical activities.[41] Furthermore, others might have problems in identifying the actual time spent in these activities. These issues may cause unusually high estimates of physical activity levels in studies using the IPAQ.[44] Therefore, objective measurement tools, rather than self-reported assessment, might have provided more accurate results with special regard to work activity.[45] Nevertheless, Kwak et al[11] showed that the IPAQ-long version provides a moderately good measure for work activity when compared with an accelerometer ($r = 0.46$; $P < 0.01$). Moreover, the IPAQ was found to have acceptable measurement properties for monitoring population levels of physical activity among 18- to 65-year-old adults in diverse settings.[22] Further strengths were the recruitment period of 1 year including seasonal variations and the adjustment for several socioeconomic variables.

On the contrary, the analyses were not controlled for food intake because no information about energy intake was available. Another limitation was the cross-sectional study design, which does not allow conclusions about causality. To determine the direction of causal relationships, longitudinal intervention studies need to be conducted. Moreover, the sample size was relatively small for evaluating the relationship between different activity domains and body composition measures. In particular, the limited number of subjects in each occupational category gave little insight into the impact of occupation. Further investigation with enlarged sample size is required to confirm our results. Finally, this study was not representative for the female population.

CONCLUSIONS

The key finding of this cross-sectional investigation is that the relationship between body composition and physical activity is domain-specific. Leisure-time activity may represent the most effective activity domain being associated with lower WC, lower relative FM, and higher relative MM. Work activity and moderate daily activities, such as walking or cycling to work as well as housework and gardening, do not seem to be protective against overweight defined by BMI, WC, and relative FM. Moreover, BMI seems to be a very limited measure to assess the association between domain-specific physical activity and body composition, and other parameters including WC, relative FM, and relative MM may be preferably used.

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