Association between physical activity patterns and anthropometric characteristics of adults: an issue of public health?

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Summary

Study aim: The aim of this study was to evaluate the association between objectively measured daily physical activity (PA) and body fat mass (BF) and body mass index (BMI). A further aim was to analyse the variance of PA between quartiles of BF and BMI.

Material and methods: A cross-sectional, observational study of 126 university students (53 males aged 20.46 ± 2.04 years and 73 female aged 19.69 ± 1.32 years) was conducted.

Results: The female participants and PA characteristics explain 57.10% of BF variance and the model was statistically significant ($F_{(6, 875)} = 196.38$; $p = 0.001$). BMI was also included in the model. Standard binary logistic regression was used to test the hypothesis that female sex and PA characteristics can influence overweight. The full model containing all variables was statistically significant ($G^2(6) = 58.598$, p-value = 0.001). Analysis of variance between BF quartiles revealed statistically significant differences in male participants in light PA ($p = 0.001$; ES = 0.09), moderate PA ($p = 0.001$; ES = 0.042) and vigorous PA ($p = 0.001$; ES = 0.130).

Conclusions: The statistical model in the regression analysis suggests that low and vigorous levels of PA explain 57% of BF variance in female participants.

Keywords: Physical activity – Accelerometry – Body fat mass – Body mass index – Young adults

Introduction

Emerging adulthood, i.e. the period of age ranging from 18 to 25 years, has been identified as a crucial transitional period, since it lies between adolescence and adulthood, and as a correlate of overweight and obesity during adulthood [15]. This period is characterized by deterioration in health-related habits, e.g. poorer eating habits and decrease of physical activity (PA) [17]. In addition, standard intervention programmes do not meet the weight control needs in this population [10]. Psychological markers in emerging adulthood were associated with less PA and a higher body mass index in adulthood [2]. Emerging adulthood also shows relatively low life satisfaction [18], whereas PA has been suggested as a mean of depression intervention in this period [5].

University students undergo physiological and psychological changes affecting their PA levels and nutrition habits, which in turn result in considerable gains in body mass [8, 13]. Also, prevalence of overweight and plasma lipid levels were found to be above normal in university students [11]. Although the abovementioned studies enhanced our understanding of the relationship between PA and markers of overweight and obesity, there is a lack of information about objectively measured PA and domains of PA, such as sedentary, light, moderate and vigorous during emerging adulthood. Instead of using objective assessment methods (e.g. accelerometer), previous studies have relied mostly on subjective methods (e.g. questionnaire) [7, 21]. In addition, sedentary, light, moderate and vigorous PA might be associated differently with BMI and BF [23]. Such information would be valuable for both researchers and health professionals involved in the management of overweight and obesity. The aim of the present study was to investigate the relationship between objectively measured PA and markers of overweight and obesity in young female and male adults.

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Materials and methods

Participants

One hundred and twenty-six university students (53 males aged 20.46 ± 2.04 years and 73 females aged 19.69 ± 1.32 years) participated in this study. From these undergraduate students, 26.19% were amateur athletes (males: n = 20; females: n = 13). Most of them lived in rented flats (63%) or in the campus hostels (19%) close to the campus, so they were not far away from the lecture halls. The Research Ethics Committee of the Polytechnic Institute of Coimbra approved this study (code: 01.09/2015). All volunteers signed informed consent forms prior to their participation in the study. The study followed the ethical standards of the Declaration of Helsinki for research on humans.

Procedures

Participants were assessed individually at a single session before wearing the accelerometer. Upon arriving at the laboratory for the session, participants completed several paper and pencil self-report measures asking about their PA and mental and physical health.

The anthropometric measurements were made at the university by trained researchers to minimize the inter-observer variability. Body mass and height were measured following standardized recommendations with an electronic scale (Tanita SC 330 S; precision = 100 g, range = 0–270 kg) and a stadiometer (model 213, SAGE, precision 0.1 cm, range = 0–230 cm), respectively. The average of two measurements was taken. Body mass index (BMI) was calculated as body mass (in kg) divided by height^2 (in meters). The BF (kg) and % of BF were also collected from the Tanita's measurement.

Immediately after completing the physical fitness testing, participants were fitted with an ActiGraph wGT3X-BT activity monitor (Shalimar, FL, USA) that they wore for the next 7 days. The wGT3X-BT is a tri-axial, solid-state accelerometer designed to measure body acceleration in the three planes. Participants were instructed to wear the accelerometers over the right iliac crest under their clothes for 24 hours including during sleep and to remove it only for showers and water-based activities such as swimming. At the end of the 7-day monitoring period participants turned in their accelerometers, and the accelerometer data were analysed using ActiLife 6.0 software.

The accelerometers were initialized and downloaded using the ActiLife software provided by the manufacturer. The data were collected in 10-s epochs. To analyse the data, the 10-s epochs were collapsed into 60-s epochs, which is a validated epoch for young adults. Non-wear time was counted as 60 consecutive minutes with zero counts, with the allowance for 1 min with counts greater than zero.

Non-wear was excluded from further analysis. Accelerometer data were processed (ActiLife 6.0.) to provide values for total daily and hourly counts per minute (cpm) sedentary time (minutes and %), light PA (minutes and %), moderate PA (minutes and %), vigorous PA (minutes and %), and steps for weekdays and weekend. The intensity of weekly PA was assessed as average cpm. The cut-off values used to define the intensity of PA and, therefore, quantify the mean time in each intensity were the following: sedentary time, ≤ 100 cpm, light PA, 101–1951 cpm, moderate PA, 1952–5724 cpm, and vigorous PA ≥ 5725. Moderate-to-vigorous PA was computed by the sum of moderate and vigorous PA.

Statistical procedures

In this study the sex (male and female) and the quartiles (lower, two middle and upper) of BF and BMI were defined as factors. The quartiles' limits of BF were computed per each sex and for the specific case of this dataset. The anthropometric variables (body mass, height) and PA variables (sedentary, light, moderate, vigorous, in minutes and number of steps) were defined as dependent variables. Comparisons were made by independent t-test (comparison between sexes) and one-way analysis of variance (ANOVA) (between BF and BMI quartiles) after validating normality and homogeneity assumptions. The BF and BMI quartiles represent three categories (lower, middle and upper), thus being factors. The middle group represents two quartiles (2nd and 3rd), the lower represents the 1st quartile, and the upper represents the 4th quartile. Effect size (ES) was presented as η^2 for one-way ANOVA and interpreted using the following criteria: no effect ($\eta^2 < 0.04$), minimum effect ($0.04 \leq \eta^2 < 0.25$), moderate effect ($0.25 \leq \eta^2 < 0.64$) and strong effect ($\eta^2 \geq 0.64$) [9]. For the case of the independent t-test, Cohen's d was calculated as ES measured using the following criteria [4]: small effect ($d < 0.2$); moderate effect ($0.2 \leq d < 0.8$); and large effect ($d \geq 0.8$). Pearson's product moment correlations were calculated in order to examine the association between anthropometric variables (BMI, %BF) and PA levels (number of steps per day, sedentary time, light PA, moderate PA and vigorous PA). The following correlation scale was adopted [16]: trivial ($r < 0.1$); small ($0.1 \leq r < 0.3$); moderate ($0.3 \leq r < 0.5$); large ($0.5 \leq r < 0.7$); very large ($0.7 \leq r < 0.9$); and nearly perfect (≥ 0.9).

Standard multiple linear regression was used to test the hypothesis that female gender and physical activity characteristics can influence the BF and BMI and also was used to test the hypothesis that BF and BMI can influence the physical activity characteristics (steps, sedentary, light PA, moderate PA and vigorous PA). First we analysed the assumptions of multiple linear regression. When in the model not all independent variables were a significant predictor we performed stepwise multiple linear regression and

analysed the assumptions. Standard binary logistic regression was used to test the hypothesis that female gender and physical activity characteristics can influence overweight. First we analysed the assumptions of binary logistic regression. When in the model not all independent variables were a significant predictor we performed binary logistic regression using the forward stepwise method (likelihood ratio) and analysed the assumptions. For all data sets each statistical technique was performed and corresponding assumptions were tested using SPSS software (version 23.0, Chicago, Illinois, USA). Statistical significance was set at $p = 0.05$.

Results

Anthropometric characteristics and accelerometry data are displayed in Table 1 by sex. Male participants were taller (7.26%), heavier (16.60%), walked more steps per day (19.82%) and spent more time in light PA (4.53%), moderate PA (24.93%) and vigorous PA (214.19%). Female participants had a greater % of BF (140.19%) and spent more time in sedentary behaviour (3.66%).

Participants were organized according to quartiles (lower, middle and upper) of % BF. PA levels were then computed and compared per quartile (Table 2). Statistically significant differences in male participants were found in light PA ($p = 0.001$; ES = 0.09), moderate PA ($p = 0.001$; ES = 0.042) and vigorous PA ($p = 0.001$; ES = 0.130). Post hoc analysis revealed that the middle quartiles spent statistically lower time in light PA, moderate PA and vigorous PA. In the analysis of female participants, a significant difference was found in light PA ($p = 0.001$; ES = 0.05). In this case, the upper quartile spent statistically more time in light PA than lower and middle quartiles.

The analysis of variance of PA levels between quartiles of BMI can be verified in Table 3. Significant differences were found in male participants between BMI quartiles in light PA ($p = 0.002$; ES = 0.032). The middle quartiles spent significantly more time in light PA than the lower and upper quartiles. In the case of female participants, significant differences between BMI quartiles were found in light PA ($p = 0.001$; ES = 0.067) and vigorous PA ($p = 0.049$; ES = 0.011). The middle quartiles spent statistically more time in light PA and vigorous PA than the lower and upper female quartiles.

Table 4 show the values of Pearson's correlation test between anthropometric variables (%BF, BMI) and PA levels (steps, sedentary, light PA, moderate PA and vigorous PA).

Table 1. Comparison of anthropometric data and PA levels between male and female participants

	Men (n = 53)	Women (n = 73)				
	M ± SD	M ± SD	t	df	*p*-value	Cohen's d (ES)
	[CI 95%]	[CI 95%]				
Height [cm]	176.66 ± 7.20 [175.93–177.40]	164.71 ± 6.59 [164.14–165.29]	25.21	754.41	0.001	1.74 Large effect
Body mass [kg]	71.52 ± 10.60 [70.43–72.60]	61.34 ± 10.24 [60.45–62.23]	14.36	880	0.001	0.98 Large effect
BMI [kg · m⁻²]	22.57 ± 2.66 [22.30–22.84]	22.64 ± 3.56 [22.33–22.95]	–0.298	879.31	0.766	–0.02 Small effect
Body Fat Mass [%BF]	10.30 ± 4.56 [9.84–10.77]	24.74 ± 7.49 [24.09–25.39]	–35.45	856.25	0.001	–2.25 Large effect
Steps [number per day]	10002.15 ± 7628.44 [9223.36–10780.94]	8347.51 ± 3994.70 [8000.34–8694.69]	3.815	517.12	0.001	0.29 Moderate effect
Sedentary time [min/day]	741.01 ± 189.89 [721.63–760.40]	768.11 ± 156.38 [754.52–781.11]	–2.25	700.82	0.025	–0.16 Small effect
Light PA [min/day]	298.70 ± 107.09 [287.77–309.63]	285.76 ± 81.93 [278.65–292.89]	1.95	664.25	0.052	0.14 Small effect
Moderate PA [min/day]	54.27 ± 42.85 [49.89–58.64]	43.44 ± 33.57 [40.52–46.36]	4.05	675.88	0.001	0.29 Moderate effect
Vigorous PA [min/day]	4.65 ± 8.01 [3.83–5.46]	1.48 ± 3.67 [1.16–1.80]	7.09	483.32	0.001	0.54 Moderate effect

Table 2. Accelerometer data in men and women with valid registrations, organized according to quartiles (lower, two middle and upper) of % BF

Men (n = 53)	Lower < 6.5% (n = 13)	Middle 6.5–12.8% (n = 27)	Upper 12.8% (n = 13)	F	*p*-value	Eta square (ES)
Sedentary time [min/day]	737.63 ± 174.16 [699.85–775.42]	743.50 ± 187.85 [717.03–769.96]	738.79 ± 209.28 [695.21–782.38]	0.036	0.965	0.001 No effect
Light PA [min/day]	313.86 ± 100.33 [292.08–335.63][b]	270.20 ± 100.90 [255.98–284.41][a,c]	346.09 ± 107.46 [323.71–368.47][a]	18.25	0.001	0.09 Minimum effect
Moderate PA [min/day]	68.46 ± 44.44 [58.82–78.11][b]	46.78 ± 39.90 [41.16–52.40][a]	57.30 ± 44.26 [48.08–66.51]	8.14	0.001	0.042 Minimum effect
Vigorous PA [min/day]	9.80 ± 11.54 [7.29–12.30][b,c]	2.59 ± 4.77 [1.91–3.26][a]	4.33 ± 7.57 [2.75–5.91][a]	27.34	0.001	0.130 Moderate effect
Women (n = 73)	Lower < 18.6 % (n = 13)	Middle 18.6–29.4% (n = 27)	Upper 29.4% (n = 13)	F	p-value	Eta square (ES)
Sedentary time [min/day]	777.58±155.42 [748.48 – 806.68]	762.75 ± 157.92 [743.69–781.82]	770.86 ± 154.82 [744.31–797.42]	0.38	0.683	0.001 No effect
Light PA [min/day]	270.90±80.08 [255.91±285.90][c]	276.70 ± 78.17 [267.26–286.13][c]	316.42 ± 83.50 [302.10–330.74][a,b]	13.41	0.001	0.05 Minimum effect
Moderate PA [min/day]	39.82±25.35 [35.08 – 44.57]	43.95 ± 34.78 [39.75–48.15]	45.46 ± 37.02 [39.11–51.81]	0.92	0.399	0.004 No effect
Vigorous PA [min/day]	1.45±3.92 [0.71 – 2.18]	1.35 ± 3.38 [0.95–1.75]	1.77 ± 4.17 [1.06–2.49]	0.60	0.550	0.002 No effect

Significantly different compared with Lower[a]; Middle[b]; and Upper[c] at p < 0.05

Table 3. Accelerometer data in men and women with valid registrations, organized according to quartiles (lower, two middle and upper) of BMI

Men (n = 53)	Lower <25 (n = 16)	Middle 25–30 (n = 26)	Upper >30 (n = 11)	F	*p*-value	Eta square (ES)
Sedentary time [min/day]	739.67 ± 184.46 [719.66–759.67]	752.57 ± 243.03 [669.09–836.06]	746.57 ± 167.24 [591.90–901.24]	0.76	0.927	0.001 No effect
Light PA [min/day]	291.85 ± 99.70 [281.03–302.66]b	353.86 ± 135.22 [307.41–400.31]a	345.00 ± 193.13 [166.39–523.61]	6.14	0.002	0.032 No effect
Moderate PA [min/day]	55.40 ± 42.93 [50.69–60.01]	49.77 ± 44.17 [34.60–64.94]	28.86 ± 18.40 [8.86–42.86]	1.844	0.160	0.010 No effect
Vigorous PA [min/day]	4.84 ± 8.05 [3.96–5.71]	3.74 ± 8.26 [0.90–6.58]	0.29 ± 0.76 [0–0.98]	1.355	0.259	0.007 No effect
Women (n = 73)	Lower <25 (n = 15)	Middle 25–30 (n = 24)	Upper >30 (n = 14)	F	p-value	Eta square (ES)
Sedentary time [min/day]	772.05 ± 159.04 [756.66–787.43]	754.85 ± 138.24 [724.85–784.85]	731.71 ± 180.90 [627.27–836.16]	0.812	0.445	0.003 No effect
Light PA [min/day]	275.50 ± 78.23 [267.93–283.6]b	331.51 ± 85.40 [312.98–350.04]a	314.21 ± 71.10 [273.16–355.27]	18.353	0.001	0.067 Minimum effect
Moderate PA [min/day]	42.20 ± 31.94 [39.11–45.29]	49.96 ± 40.88 [41.09–58.84]	40.71 ± 29.70 [23.56–57.87]	1.919	0.148	0.008 No effect
Vigorous PA [min/day]	1.38 ± 3.42 [1.05–1.71]c	2.21 ± 4.88 [1.15–3.27]c	0.07 ± 0.27 [0–0.23]a,b	2.885	0.049	0.011 No effect

Significantly different compared with Lower[a]; Middle[b]; and Upper[c] at p < 0.05

Table 4. Pearson's correlation test between anthropometrics and PA levels

	Steps	Sedentary	Light PA	Moderate PA	Vigorous PA
Body Fat mass (BF)	−0.122** Small correlation	0.079* Trivial correlation	0.058 Trivial correlation	−0.117 Small correlation	−0.259** Small correlation
BMI	0.048 Trivial correlation	0.040 Trivial correlation	0.253** Small correlation	0.029 Trivial correlation	−0.051 Trivial correlation

*p-value<0.05; **p-value<0.01

Standard multiple linear regression was used to test the hypothesis that female sex and PA characteristics can influence the BF and BMI (Table 5). Female sex and PA characteristics explained 57.10% of BF variation and the model was statistically significant ($F_{(6, 875)}$ = 196.38; p = 0.001). Female sex, light PA and vigorous PA were revealed to be significant predictors of BF variation. In *BMI*,

Table 5. Standard multiple linear regression (method: Enter)

	Dependent variables (unstandardized β and significance)	
Model	BF	BMI
(Constant)	6.601	19.379
Sex (Female)	14.113*	0.012
Steps	0.0001	−0.000023
Sedentary	0.001	0.001
LightPA	0.014*	0.010*
ModeratePA	0.006	0.001
VigorousPA	−0.119*	−0.040
R²	0.574	0.075
Adjusted R²	0.571	0.069

* − p < 0.008

Table 6. Multiple linear regression (method: Stepwise)

	Dependent variables (unstandardized β and significance)	
Model	BF	BMI
(Constant)	7.262	20.081
Sex (Female)	14.144*	–
LightPA	0.012*	0.009**
VigorousPA	−0.143*	−0.048**
R²	0.572	0.072
Adjusted R²	0.57	0.07

* − p-value< 0.017; ** − p < 0.025

the results showed that female sex and PA characteristics explained 6.9% of the variation and the model was statistically significant ($F_{(6, 875)}$ = 11.902; p = 0.001). Light PA was found to be a significant predictor of this variable.

According to the stepwise multiple linear regression (Table 6), female sex, light PA and vigorous PA explained ~57% of BF variation and the model was statistically significant ($F_{(3, 878)}$ = 390.639; p = 0.001). In *BMI*, the results showed that light PA and vigorous PA explained ~7% of the variation and the model was statistically significant ($F_{(2, 879)}$ = 34.166; p = 0.001).

Standard multiple linear regression was used to test the hypothesis that BF and BMI could influence PA characteristics (steps, sedentary, light PA, moderate PA and vigorous PA) (Table 7). BF and BMI explained 3.1% of steps variation and the model was statistically significant ($F_{(2, 879)}$ =15.054; p = 0.001). In sedentary time, the results showed that BF and BMI explained 0.4% of the variation and the model was not statistically significant ($F_{(2, 879)}$ = 2.757; p = 0.064). In light PA, the results showed that BF and BMI accounted for 7.1% of the variation and the model was statistically significant ($F_{(2, 879)}$ = 34.485; p = 0.001). In light PA, the results showed that BF and BMI explained 7.1% of the variation and the model was statistically significant ($F_{(2, 879)}$ = 34.485; p = 0.001). In moderate PA, the results showed that BF and BMI accounted for 2.3% of the variation and the model was statistically significant ($F_{(2, 879)}$ = 11.493; p = 0.001). In vigorous PA, the results showed that BF and BMI explained 7.6% of the variation and the model was statistically significant ($F_{(2, 879)}$ = 37.365; p = 0.001).

Standard binary logistic regression was used to test the hypothesis that female sex and PA characteristics could influence overweight (Table 8). The full model containing all predictors was statistically significant ($G^2(6)$ = 58.598; p = 0.001), indicating that the model was able to distinguish between overweight and not overweight. The Hosmer-Lemeshow test indicated support for the model (X^2 =13.2; p = 0.105). The model as a whole explained between 6.4% (Cox and Snell R²), 11% (Nagelkerke R²) and 7.6% (McFadden R²) of the variance in overweight status, and correctly classified 84.1% of cases. The sensitivity and specificity of the model are, respectively, 5% and 99.5%.

Table 7. Standard multiple linear regression (method: Enter)

Model	Steps	Sedentary	Light PA	Moderate PA	Vigorous PA
			Dependent variables (unstandardized β and significance)		
(Constant)	4774.103	734.491	105.239	27.053	1.323
Body Fat mass (BF)	−127.283*	1.450	−1.086*	−0.741*	−0.208*
BMI	293.921*	−0.215	9.122*	1.538*	0.237*
R^2	0.033	0.004	0.073	0.023	0.078
Adjusted R^2	0.031	0.006	0.071	0.025	0.076

$* - p < 0.025$

Table 8. Logit coefficients of standard binary logistic regression of the dependent variable overweight

Independent variables	B	S.E.	X^2_{Wald}	df	p-value	Exp(B) (odds ratios)	95% CI for EXP(B) Lower	Upper
Steps	0.000	0.000	4.577	1	0.032	1.000	1.000	1.000
Sedentary	0.000	0.001	0.111	1	0.739	1.000	0.999	1.001
LightPA	0.008	0.001	40.830	1	0.000	1.008	1.006	1.011
ModeratePA	0.009	0.006	2.245	1	0.134	1.009	0.997	1.021
VigorousPA	0.004	0.021	0.033	1	0.856	1.004	0.964	1.045
Sex (Female)	0.735	0.217	11.486	1	0.001	2.085	1.363	3.189
Constant	−3.849	0.663	33.653	1	0.000	0.021		

As shown in Table 8, only three of the independent variables made a unique statistically significant contribution to the model (female sex, light PA and steps).

After performing the binary logistic regression using the forward stepwise method (likelihood ratio), the new model containing only the predictors light PA (B = 0.006; X^2_{Wald} (1) = 40.611; p = 0.001; OR=1.006 (95% CI (1.004–1.008)) and female sex (B = 0.805; X^2_{Wald} (1) = 14.78; p = 0.001; OR=2.236 (95% CI (1.484–3.370)) was statistically significant ($G^2(2)$ = 52.349; p = 0.001), indicating that the model was able to distinguish between overweight and not overweight. The Hosmer-Lemeshow test indicated support for the model ($X^2(8)$ = 13.79; p = 0.087). The model as a whole explained between 5.8% (Cox and Snell R^2), 9.9% (Nagelkerke R^2) and 9.22% (McFadden R^2) of the variance in overweight status, and correctly classified 84.2% of cases. The sensitivity and specificity of the model are, respectively, 2.1% and 99.7%. The area under the ROC curve is c = 0.686 (p = 0.001), which can be interpreted to mean that a randomly selected individual from the overweight group has a test value larger than that for a randomly chosen individual from the not overweight group 68.6% of the time.

In Figure 1 it can be seen that, for the same light PA, the probability of a female being overweight is much higher than the probability of a male being overweight.
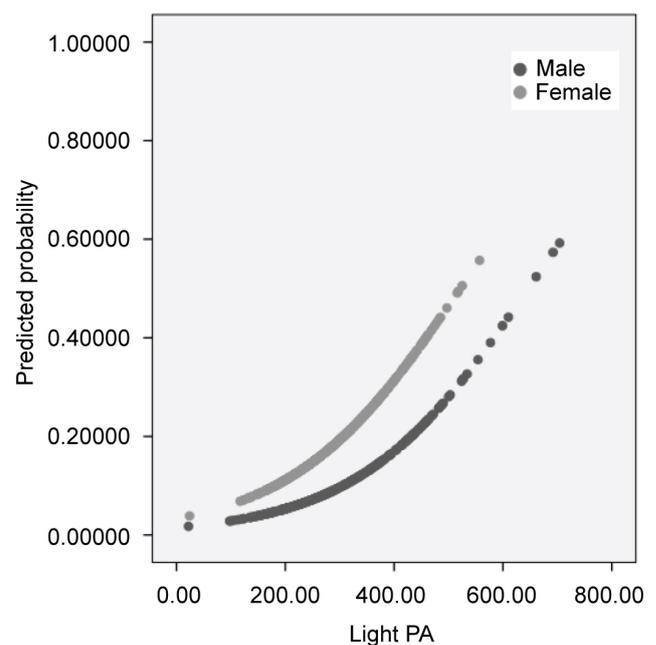
Fig. 1. Probability of female and male participants being overweight

Discussion

This study aimed to analyse the association between anthropometric characteristics and PA levels of university students. A further aim was to analyse the variance of PA levels between quartiles of BF and BMI. The main results revealed that PA patterns can explain 57.9% of the BF, although PA only may explain 6.9% of BMI. Particularly, light PA was found to be a significant predictor of the BF dimension. In the other hand, standard multiple linear regression was used to test the hypothesis that BF and BMI can influence the PA levels and the results revealed that the time in vigorous PA can explain 7.6% of the variance in both anthropometric variables. The analysis of variance between BF quartiles showed statistically significant differences in male participants in light PA, moderate PA and vigorous PA. The variance between BMI quartiles revealed significant differences between BMI quartiles in light PA and vigorous PA of female participants.

Some studies have linked PA with healthy behaviours of children, adults and the elderly [1, 27, 28]. As far we know, no longitudinal study that analysed the effects of PA in health parameters has reported negative results over time [23]. Daily PA levels have been negatively related to the body mass gain over the years [12, 22, 25] and the incident risk of type 2 diabetes mellitus [25]. Moreover, PA is associated with decreased rates of coronary heart disease [3]. Such evidence seems to highlight the importance of daily PA to ensure good health and quality of life. Based on that, this study analysed the effects of PA on the body composition of young adults studying in a university environment.

The rationale to study university students is the great change in life style and the critical period that they experience after finishing high school [8, 13]. The standard multiple linear regression for female sex (dummy variable) revealed that light PA and vigorous PA were significant predictors of BF, thus suggesting that being active or inactive may be associated with changes of body composition that conversely may lead to a healthy or non-healthy status. The American College of Sports Medicine highlights that light PA is not enough to prevent overweight, thus suggesting cardiorespiratory exercise at moderate-to-vigorous intensity for 150 min per week, at least [19]. In female participants, the analysis per BF quartile only revealed significant differences in light PA. Surprisingly, the upper group of BF (>29.4% BF in females) spent significantly greater time in light PA than middle and lower quartiles. In the case of male participants, the analysis of variance between quartiles of BF revealed that the upper limit (>12.8% BF) had significantly lower levels of light PA, moderate PA and vigorous PA time per day than the lower limit (<6.5% BF). Interestingly, the upper group

had greater values of activity than the middle group. Such a result may be justified by the fact that the middle group represents two quartiles (2nd and 3rd) and such a methodological decision may have covered the evidence. Another explanation could be the Hawthorne effect that may have occurred in the upper group since they only wore the accelerometer for one week.

The lack of significant results in the analysis of variance of PA levels between quartiles of BF and BMI may be explained by the worse Hawthorne effect (reactivity to their awareness of being observed). Some participants may have been more active than normal, thus influencing the results. On the other hand, an interesting and singular study that tracked the long-term effect of leisure time PA in 3653 women and 2626 men revealed that the results did not support the fact that medium or high PA at baseline prevents obesity in the long term [20]. In fact, the authors suggested that among the more active subjects there were more obese ones later on [20]. Despite the small and non-usual evidence, our results suggested a balanced bias in PA levels of different groups of BF and BMI.

Besides the association of PA levels to explain BF and BMI, a reverse analysis tried to analyse whether BF and BMI can explain the PA levels (based on sociocultural and psychological engagement). For the dummy variable of female sex, the results revealed that BF and BMI explained 7.1% of the variance in light PA, 2.3% of moderate PA and 7.6% of vigorous PA. Therefore, it is possible that body composition may constrain PA levels. Thus such a hypothesis must be considered in future studies: Is it the body composition that influences physical activity, or vice versa? We found no studies that analysed the psychological conditions that associate the body image with the pursuit of an active life style in university studies. This should be considered in future studies. Finally, the model that used light PA was able to predict overweight in university students (BMI >25) with a rate of 84%, thus suggesting that the time spent in light activities may be crucial to a healthy life style [14].

Finally, analysis of variance revealed significant differences in body composition and PA patterns between sexes. It was observed that males are significantly more active than females, especially doing more moderate-to-vigorous activities. On the other hand, females were significantly more sedentary and revealed significantly greater values of BF but not BMI. Our results are in line with previous studies that showed higher PA levels of men in comparison with women [2, 4]. The differences in BF are normal considering the specific composition of men and women and the differences in fat metabolism [3]. Such results may be used to define some different interventions taking into account the specificities of each sex.

This study had some limitations. The use of accelerometers for only 7 consecutive days may have contributed

to the occurrence of the Hawthorne effect, particularly in groups in upper limits of BF and BMI. An extended period up to four weeks may help to avoid this problem in future studies. Another limitation of this study was that some of the participants were sports students or amateur athletes (26.19%), thus increasing the PA patterns in some of them, even in students with greater values of BF or BMI. Future studies should consider not including these particular groups to test the homogeneity of the sample. Finally, this study did not use the most precise and up-to-date devices to test BF. Dual-energy X-ray absorptiometry or air displacement plethysmography technology would be more accurate methods to determine BF than electronic scales. Nevertheless, despite the bioelectrical impedance analysis used in this study not being the most appropriate choice for body composition measurement, the appropriate algorithms for the population can accurately measure BF [6].

Translation to health education practice

The results obtained from this study suggest that light PA may predict the overweight participants. Moreover, PA levels may explain more than 50% of the BF variation, thus suggesting that activity patterns should be considered in health programmes and government policies to prevent and reduce overweight and obesity. Future studies should consider adopting a longitudinal study with objective measurement of PA, trying to identify the adaptations to specific critical periods such as the first job, the family constitution or the adaptation to become a mother or father. Should PA levels in university students determine the style of life in older stages? May PA patterns across life determine the anthropometrics and occurrence of diseases? These research questions can be the next step to follow after our study.

Conclusions

The results of this study indicate that PA levels of university students may predict BF and BMI. Moreover, light PA was found to be a predictor of overweight participants. Both results confirm that PA and anthropometric characteristics are associated and should be considered to prevent obesity. On the other hand, the analysis of variance between BF and BMI quartiles also revealed that PA could not be the only contributing factor to reduce obesity and overweight in young adults. This study concludes that body composition can be influenced by PA levels and for that reason specific programmes of exercise must be adopted by government policies to promote a healthy life style in young adults. Future studies should consider following up the population across different stages of their life span and organize different experimental groups with diverse PA levels, nutritional control and other interventions that complement the benefits of PA and exercise.

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