The 6-min Walk Test Reflects Functional Capacity in Primary Care and Obese Patients

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Key words
- physical fitness
- quality of life
- primary care
- obesity

Abstract

The main purpose of this study was to determine the association between the 6-min walk test distance (6MWTD) and physical functional capacity (PF) in primary care patients, as well as in obese individuals. We studied 351 subjects (age = 56.8 ± 14.6 years; BMI = 29.4 ± 5.7 kg/m^2; 68 % women), including 141 obese subjects (BMI ≥ 30 kg/m^2), recruited in 10 different family practices. Physical (PCS) and mental component summary of the health-related quality of life (HRQOL) and the 8 sub-scores were measured using the Short Form-36 Health Survey. Anthropometry, vital signs and physical testing were measured according to standardized protocols. Recreational physical activity (LPA) and sedentary levels were determined using the Canadian Community Health Survey. In a stepwise multivariate analysis, 65 % of the 6MWTD variance was explained by PF of the HRQOL, age, quadriceps strength, number of chronic diseases, LPA categories, BMI, resting heart rate, PCS, height and TV-viewing categories in primary care subjects. In the obese individuals, PF, age, quadriceps strength and BMI explained 57 % of the 6MWTD variance. In these 2 groups, 44 % of the 6MWTD variance is explained by PF only. To conclude, the 6MWTD is strongly associated with PF of the HRQOL. Thus, it adequately reflects physical limitations in daily life activities of primary care patients, including obese individuals.

Introduction

The 6-min walk test (6MWT) is a sub-maximal test, currently used in clinical practice and research because it is inexpensive, simple, well-tolerated and validated in several populations [1, 3, 6, 8, 18, 22, 33, 39, 43]. The 6MWT reflects physical fitness, since its associations with muscular strength and maximal aerobic capacity are well known in the literature [3, 14, 15, 28, 49].

The 6MWT is also widely described as reflecting functional capacity in the literature [1, 10, 18, 22, 24]. While some authors define functional capacity as the ability to undertake physically demanding activities of daily living, others use broader definitions encompassing the areas of physical, mental, and social functioning [43]. Beyond the semantic debate, it would be interesting to know if the 6MWT distance (6MWTD) is independently associated with the various components of the functional capacity (physical, mental and social).

Health-related quality of life (HRQOL) has been defined as embracing a wide range of physical and psychological characteristics (and limitations) that describe a person's functional capacities [27]. It also appraises the satisfaction of patients with current functional levels as compared to what they view as the ideal [27]. The 6MWTD appears to be associated with the physical component of the HRQOL in the elderly and in subjects with morbid obesity, cardiovascular diseases and bronchiectasis, but less with the mental component [4, 23, 24, 34, 48]. Consequently, it is assumed in the literature that the 6MWT reflects physical functional capacity and impaired quality of life [16, 18, 21].

The 6MWT distance is also associated with several socio-demographic (sex, age), anthropometric (weight, height, body mass index (BMI)) and physiological factors (physical fitness and capacity, comorbidities, cognitive deficit, resting heart rate, smoking status) in healthy and unhealthy adults [10–12, 14, 17–19, 28, 33, 36, 40]. The influence of physical activity and sedentary levels on 6MWTD is unclear since some studies found moderate associations [5, 23, 28, 29] and others did not [9, 11, 20, 49].

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Consequently, the associations of the 6MWT in specific populations (healthy, elderly, subjects with specific illness) have been extensively studied. However, to our knowledge no data are available in a population with various health statuses as primary care patients. In addition, data are missing on the association between 6MWTD and functional capacity, physical activity and strength in class I to III obese individuals, since such studies have been performed only in women [28] or in subjects with morbid obesity [12,48].

Thus, the main purpose of this study was to determine whether the 6MWTD is independently associated with functional capacity in primary care patients, as well as in the subgroup of obese individuals. We also sought to identify other independent associations between the 6MWTD and socio-demographic, anthropometric, physiological and behavioral (physical activity and sedentary levels) factors in these 2 populations.

Materials and Methods

Population

The data used for this study was part of a prospective interventional study [2]. Briefly, 439 patients were recruited for the interventional study in 10 different Family Medicine Groups (FMGs) within the territory of the Integrated University Health Network of the Centre hospitalier universitaire de Sherbrooke (CHUS) and the Université de Sherbrooke, between 2009 and 2012.

To be included in the "targeted diseases group", patients had to have hypertension, dysglycemia or diabetes in addition to a BMI ≥ 25 kg/m^2 and having seen a physician at least 4 times in the last 2 years. Patients were included in the "regular follow-up group" if they had seen a physician at least twice during the last 2 years and did not have targeted chronic diseases. Patients were excluded if they had a diagnosis of cancer in the last 5 years (except skin cancer) or any condition having an impact on weight or lifestyle (e.g. eating disorder, Crohn's disease, etc.). For our analyses, only subjects who have performed the 6MWT were included (n = 351, including 139 in the targeted diseases group and 212 in the prevention group). The lack of physical space in some FMGs explains why some subjects did not perform the 6MWT. Each subject provided written informed consent to participate in the study. The project was approved by the Institutional Ethics Review Board of research on humans of the CHUS and the Université de Sherbrooke, and meets the ethical standards of the journal [25].

Medical history and socio-demographic data

The socio-demographic data and smoking status were self-declared in a questionnaire. A trained research coordinator reviewed medical charts for the following chronic diseases: hypertension, dyslipidemia, type 2 diabetes, heart or lung disease, sleep apnea, anxiety, depression and arthritis/osteoarthritis. The total number of chronic diseases was calculated by summing each chronic disease status cited above.

Anthropometric measures and body composition

Height was obtained to the nearest 0.1 cm using a stadiometer, and weight was measured to the nearest 0.1 kg with a calibrated scale (Tanita TBF-310®). BMI, calculated using weight (kg) divided by squared height (m^2), was used to categorize subjects with obesity (BMI ≥ 30 kg/m^2). Fat mass (FM) was measured by bipolar electric bioimpedance (Tanita TBF-310®). Standing foot-to-foot electric bioimpedance has been shown to be reliable compared to underwater weighing and to conventional supine tetrapolar bioimpedance [7,44].

Physical fitness

The 6MWT was administered on an indoor 20-m corridor, according to the American Thoracic Society recommendations [1]. The subjects were instructed to walk the longest distance in 6 min, i.e. they had to walk as fast as possible in 6 min. After 6 min, the distance covered was measured to the nearest meter.

The calibrated JAMAR® hand dynamometer was used to assess the grip strength [37,38]. According to the manufacturer's instructions, subjects sat with their shoulders adducted and neutrally rotated and elbow flexed at 90°, and had to squeeze as hard as they could. The best result of 3 measurements was recorded and the average of the results each arm was used for analyses. Peak isometric quadriceps strength has been evaluated with hand-held force dynamometers (MicroFET2®, Hoggan Health Industries®). Differences between hand-held dynamometry and the gold standard isokinetic testing were found to be minimal according to a systematic review of literature [45]. In order to reduce the bias induced by the testers' strength [32], subjects sat with the evaluated leg placed at 120° and were instructed to push as strong as possible for 5 s against the hand-held dynamometer retained by a band attached to a chair. The best result of 3 measurements was recorded, and the average of both leg results was used for analyses.

Recreational physical activity and sedentary levels

Recreational physical activity and sedentary levels were evaluated using a questionnaire from Statistics Canada for the Canadian Community Health Survey [47]. Subjects were asked about recreational physical activity over the past 3 months (duration and frequency) and the amount of time they spent watching TV during a normal week (categorical range duration). The physical activity index (PAI), expressed in kcal/kg/day, was calculated by summing the energy expenditure of each activity, as recommended by Statistics Canada [46]. Energy expenditure is calculated as: (duration × frequency × metabolic equivalent of the physical activity)/91 days. The total score was used to categorize subjects as inactive (< 1.5 kcal/kg/d), moderately active (1.5 to < 3 kcal/kg/d), and active (≥ 3 kcal/kg/d).

Health-related quality of life (HRQOL)

The Short Form-36 (SF-36) is an 8-scale profile of functional health and well-being scores as well as psychometrically-based physical and mental health summary measures.

The SF-36 questionnaire facilitates the assessment of a patient's HRQOL [50]. It is a generic questionnaire, assessing 8 HRQOL domains: physical functional capacity (PF), bodily pain, general health perceptions, vitality, physical role functioning, emotional role functioning, social role functioning and mental health. Physical (PCS) and mental summary scores (MCS) were calculated from these 8 domains [50]. The closer the score is to 100, the better the HRQOL.

Statistical analyses

The same analyses were performed in the overall primary care population (n = 351) and in the subgroup of obese individuals (n = 141). The distribution of the variables was evaluated using Normal Quintal Plots and Kolmogorov-Smornov test. If data were not normally distributed, descriptive results are presented as median (25th–75th percentiles). The normally distributed continuous variables are presented as mean values (±standard deviation), and categorical variables are presented as frequencies (percentages). Correlations between 6MWTD and other variables were performed using Pearson or Spearman's correlation test, according to the normality of their distributions. One way ANOVA was performed to compare the 6MWTD across the different categories of physical activity, TV-viewing hours and chronic diseases, followed by Tukey's tests as *post hoc* analyses. Variables significantly associated with 6MWTD in univariate analyses ($p<0.05$) and not collinear were tested in a forward-backward stepwise multivariate analysis in the primary care population in order to determine variables independently associated with 6MWTD. The same stepwise method was used in obese sub-group, but a maximum of 14 variables were included in the model in order to maintain appropriate statistical power. Anxiety and depression were excluded from the calculation of the number of chronic diseases in the univariate and multivariate analyses, because these 2 mental disorders were not significantly associated with the 6MWTD (unpaired Student t tests) in our sample. Data were analyzed with SPSS version 17.0 (SPSS Inc., Chicago, IL). The null hypothesis was rejected at $p<0.05$.

Results

Subjects characteristics

Results of the primary care population as well as the subgroup of obese individuals for anthropometric and clinical characteristics, HRQOL scores, and physical capacity and activity levels are presented in **Table 1**. Only 21% of subjects (n=72) had normal BMI (<25 kg/m^2), 39% (n=138) were overweight, and 25% (n=89) were class I, 11% (n=40) class II and 3% (n=12) class III obese individuals. Among the chronic diseases presented in **Fig. 1**, 36% (n=125) of the primary care population had no chronic disease, 23% one (n=79), 18% two (n=63) and 24% three or more (n=84). Among those with obesity, 20% (n=28) had no chronic disease, 21% one (n=30), 23% two (n=32) and 36% three or more (n=51). Among the primary care population and obese individuals, women were significantly shorter and had a lower weight (all $p\leq0.001$). Women were younger than men ($p=0.018$) only in the primary care population.

Associations with the 6MWTD

Correlations with the 6MWTD are depicted in **Table 1**.
Fig. 2 illustrates the 6MWTD according to recreational physical activity and TV-viewing hours categories in the primary care population. Inactive subjects and those watching TV more than 20 h/week had a significantly shorter 6MWTD compared to the

Table 1 Population characteristics and correlations with the 6-min walk test distance.

	Primary care population#			Obese subjects		
	N	Mean ± SD ##	r	N	Mean ± SD ##	r
sex (% women)	351	67.8	NS	141	66.7	*
age (year)	351	56.8 ± 14.7	−0.51 **	141	60.1 ± 11.5	−0.46**
waist circumference (cm)	339	96.3 ± 15.9	−0.41**	134	110.3 ± 11.1	−0.20 *
height (cm)	351	163.9 ± 9.1	0.28**	141	163.0 ± 8.4	0.30**
weight (kg)	351	78 (65.9 – 89.3)	−0.24**	141	90.1 (80.6–101.1)	−0.01
body mass index (kg/m^2)	351	28.8 (25.5–32.6)	−0.45**	141	33.4 (31.7–36.6)	−0.28**
fat mass (%)	347	34.8 ± 8.9	−0.42**	138	41.0 ± 6.4	−0.18*
systolic blood pressure (mmHg)	350	124.9 ± 15.6	−0.22**	140	128.4 ± 15.8	−0.20**
diastolic blood pressure (mmHg)	350	77.3 ± 10.0	0.02	140	78.4 ± 10.7	0.11
HbA1c (%)	344	5.8 (5.5–6.2)	−0.41 **	141	6.0 (5.7–6.5)	−0.28**
resting heart rate (beat/min)	349	68.0 (61.0–77.0)	−0.13*	140	70.5 (63.1–79.4)	0.03
number of comorbidities	351	1 (0–2)	−0.55**	141	2.0 (1–3)	−0.44**
number of smokers (%)	351	14.8	NS	141	9.2	NS
Health related quality of life scores						
physical functional capacity	349	50.7 (44.4–54.9)	0.62**	139	46.5 (38.1–52.8)	0.58 **
role physical	349	49.5 (39.7–56.9)	0.49**	141	44.6 (37.3–54.4)	0.48**
body pain	350	46.0 ± 10.9	0.43**	141	42.0 ± 10.5	0.35**
general health	350	50.6 (44.8–57.0)	0.34**	141	46.2 ± 9.8	0. 26**
vitality	350	51.2 ± 8.7	0.25**	141	49.1 ± 9.2	0.24**
social functioning	350	51.4 (40.5–56.9)	0.16 **	141	45.9 (40.5–56.9)	0.15
pole emotional	350	52.0 (40.3–55.9)	0.21 **	141	44.2 (36.4–55.9)	0.14
mental health	350	48.6 ± 9.0	0.05	141	47.1 ± 9.7	−0.04
physical component summary	347	49.3 (42.1–56.1)	0.56 **	139	45.0 (36.1–51.3)	0.56**
mental component summary	347	49.1 ± 9.4	−0.05	139	48.1 ± 10.4	−0.13
Physical capacity and activity						
recreational PAI (kcal/kg/day)	351	1.3 (0.5–2.4)	0.28**	141	0.92 (0.3–1.8)	0.24**
grip strength (kg)	349	29.9 ± 11.4	0.37**	140	29.3 ± 11.9	0.47**
isometric quadriceps strength (kg)	350	24.2 ± 10.0	0.35**	140	24.4 ± 9.8	0.47**
6-min walk test distance (m)	351	488.9 ± 108.7		141	441.1 ± 103.9	

PAI = physical activity index; * = $p<0.05$; ** = $p\leq0.005$; NS = non-significant

including obese population

Nonparametric data are presented with median (25th–75th percentiles) and categorical data as frequencies (percentages)

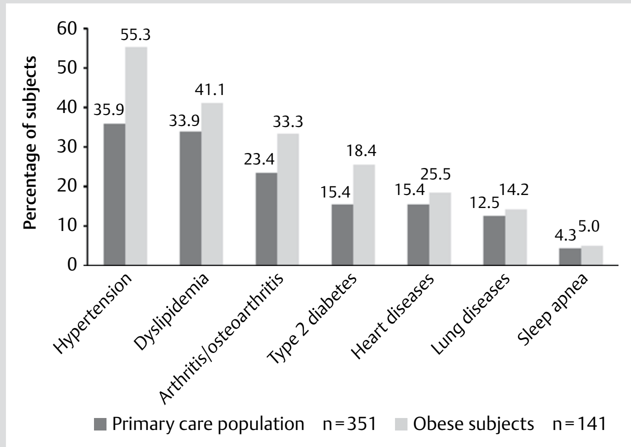

Fig. 1 Percentage of primary care population and obese subjects with various chronic diseases, as reported in clinical charts.

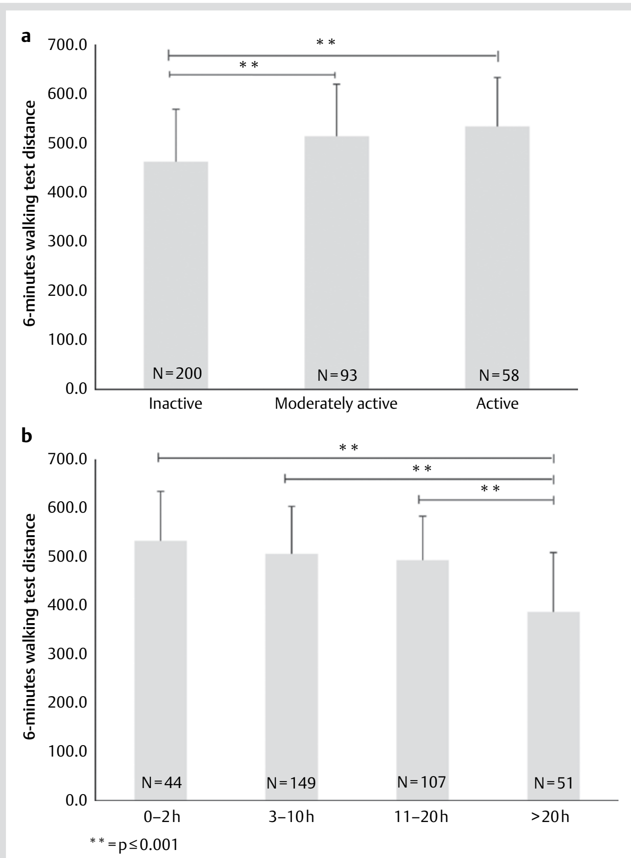

Fig. 2 The 6-min walk test distance according to **a** recreational physical activity level **a** and TV-viewing hour categories **b** in the primary care population. * * = p ≤ 0.001.

other categories (all p ≤ 0.001). In obese individuals, those viewing TV more than 20 h/week had a significantly shorter 6MWTD (396.0 [246.0–440.0] meters; n = 15) compared to subjects viewing TV between 0–2 h/week (464.0 [394.0–545.0] meters; n = 23), 3–10 h/week (455.1 ± 100.0; n = 57) and 11–20 h/week (460.4 ± 73.3; n = 46) (all p ≤ 0.001). However, no significant 6MWTD difference was found between inactive (445.0 [389.0–500.0]; n = 99), moderately active (481.0 [393.5–542.5]; n = 25) and active subjects (480.0 [412.8–545.0]; n = 17) (p = 0.071).

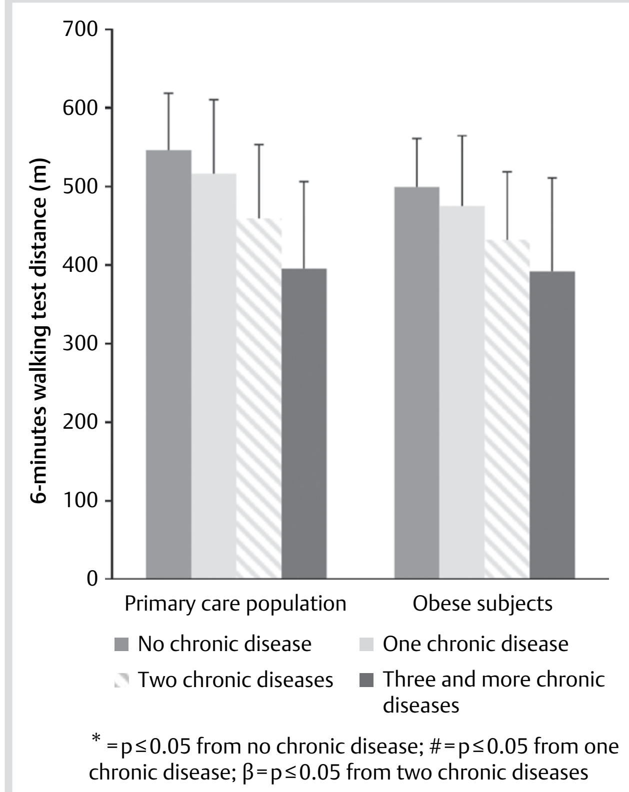

Fig. 3 The 6-min walk test distance according the number of chronic diseases in the primary care population **a** and the subgroups of obese subjects **b**. * = p ≤ 0.05 from no chronic disease; # = p ≤ 0.05 from one chronic disease; β = p ≤ 0.05 from 2 chronic diseases.

Except for anxiety (p = 0.12) and depression (p = 0.90), all chronic diseases significantly reduced the 6MWTD in the primary care population (p ≤ 0.05). In addition to anxiety (p = 0.19) and depression (p = 0.53), dyslipidemia (p = 0.74) and sleep apnea (p = 0.07) did not significantly alter the 6MWTD in obese individuals. ▶ **Fig. 3** shows the 6MWTD according to the number of chronic diseases in the primary care population and subgroup of obese individuals.

Multiple regression analyses

65 % percent of the 6MWTD variance was explained by parameters presented in ▶ **Table 2** in primary care subjects, and 57 % of the variance was explained by variables reported in ▶ **Table 3** in obese individuals. 44 % of the 6MWTD variance was explained by PF alone in the 2 analyses.

Discussion

The present study shows that, among studied variables, the 6MWTD is the most important independent factor associated with physical functional capacity (PF), assessed by the HRQOL, in primary care patients and obese individuals. The 6MWTD is also associated, to a lesser extent and not necessarily independently, with parameters reflecting socio-demographic, anthropometric and physiological status in this population.

The 6MWT is widely described in the literature as a good indicator of functional capacity [1, 10, 18, 22, 24]. In our study, PF and PCS of the HRQOL were independently associated with the

Table 2 Stepwise analysis to explain 6-min walk test distance variability in primary care subjects (N = 342).

Model	Partial p-values										Model r^{2*}	Model p-values
	Physical functional capacity score HRQOL	Age	Grip strength	Number of chronic diseases	Physical activity category	Body mass index	Quadriceps strength	Resting heart rate	Physical component summary HRQOL	TV viewing category		
1	< 0.001										0.409	< 0.001
2	< 0.001	< 0.001									0.517	< 0.001
3	< 0.001	< 0.001	< 0.001								0.557	< 0.001
4	< 0.001	< 0.001	< 0.001	< 0.001							0.597	< 0.001
5	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001						0.618	< 0.001
6	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.007					0.626	< 0.001
7	< 0.001	< 0.001	0.013	< 0.001	< 0.001	0.002	0.003				0.635	< 0.001
8	< 0.001	0.001	0.011	< 0.001	0.001	0.002	0.003	0.019			0.640	< 0.001
9	0.004	< 0.001	0.008	< 0.001	0.001	0.003	0.010	0.014	0.034		0.644	< 0.001
10	0.005	< 0.001	0.010	< 0.001	0.018	0.005	0.002	0.020	0.036	0.041	0.648	< 0.001

* = adjusted for the number of variables; HRQOL = Health related quality of life

6MWTD, whereas no social or mental component of the HRQOL was an independent predictor. Thus, the 6MWTD reflects the physical component of the functional capacity in primary care patients and obese individuals, as it was previously reported for elderly individuals and subjects with morbid obesity, cardiovascular diseases and bronchiectasis [4, 23, 24, 34, 48]. Thereby, subjects with a lower ability to undertake physically demanding activities of daily living have a reduced 6MWTD. Given that walking is a daily life activity, we can suppose that a reduced ability to walk leads to impaired PF.

In accordance with our findings, most studies in healthy and non-healthy subjects have demonstrated that shorter and older individuals have a lower 6MWTD [20, 23, 29, 30, 41, 49]. BMI was also significantly associated with 6MWTD in our study as reported in numerous studies [10, 33, 36, 40]. Significant 6MWTD difference between women and men were found in obese individuals in our study, with a trend in the primary care population (p = 0.07). The assumption that females have a shorter 6MWTD is equivocal in the literature with studies showing significant differences [10, 11, 19, 20, 23, 34] and others none [12, 17, 33]. This sex difference may be explained mainly by the difference in height [12, 18], as found in our results.

The mean 6MWTD of our primary care population (487.9 ± 109.8 m) is clearly below that of healthy and elderly healthy subjects (560–631 m) [9, 11, 18, 19, 41, 49], probably due to the presence of many chronic diseases in our sample. Indeed, in our multiple regression analyses the number of chronic diseases was an independent predictor of the 6MWTD. This is in line with previous studies showing that the presence of some chronic diseases (diabetes, obesity, hypertension, arthritis, lung and cardiac diseases) and cardiovascular risk markers (high systolic blood pressure, lipids profile and fasting glucose) reduced the 6MWTD [13, 17–19]. However, we found no association between depression, anxiety and smoker status with the 6MWTD, in contrast to some studies [13, 17, 18, 30].

In our subgroup of obese individuals, the mean 6MWTD (440.3 ± 106.3) was close to the findings of one study performed in obese subjects of similar age [26], below published results in younger obese individuals (534–591 m) [10, 17, 28, 33] and similar to younger morbidly obese individuals (414–489 m) [12, 36, 42, 48].

Age, peak isometric quadriceps strength, number of chronic diseases, recreational physical activity categories, BMI, resting heart rate, PCS, height and TV-viewing categories in the primary care population, and age, peak isometric quadriceps strength and BMI in obese population explained another 21 and 13 % of the 6MWTD variance, respectively. These results are consistent with studies carried out in various populations [12, 15, 28].

Several limitations should be considered when interpreting our results. The recruitment procedure has resulted in an overrepresentation of overweight subjects with prediabetes and diabetes, such that our results do not represent the general population of patients followed in Quebec Primary Care Groups. About 35–43 % of the variance in 6MWTD remains unexplained by our models, suggesting that other factors not assessed in our study also explain independently the 6MWTD, such as VO_2max, cognition, acute pain. In addition, we studied only self-reported recreational physical activity level, such that recall and desirability biases may have influenced participants' answers [31, 35]. The absence of a measure of total level of physical activity may have reduced the importance of this association in the explanation of the 6MWTD variance.

Model	Partial p-values					Model r^{2*}	Model p-values
	Physical functional capacity score HRQOL	Age	Quadriceps strength	Body mass index	TV viewing category		
1	<0.001					0.390	<0.001
2	<0.001	<0.001				0.501	<0.001
3	<0.001	<0.001	0.001			0.537	<0.001
4	<0.001	<0.001	0.002	0.002		0.565	<0.001
5	<0.001	<0.001	0.004	0.001	0.036	0.576	<0.001

* = adjusted for the number of variables; HRQOL = Health related quality of life

Table 3 Stepwise analysis to explain 6-min walk test distance variability in obese subjects (N = 138).

In conclusion, the 6MWTD is associated with age and parameters reflecting anthropometric and physiological status in subjects with various health statuses, as found in the primary care setting. PF assessed by the HRQOL, which reflects physical limitations in daily life activities, is strongly associated with the 6MWTD in primary care patients and obese individuals, and conversely associated with the socio-psychological component of the HRQOL. Thus, in clinical practice a smaller 6MWTD reflects a lower self-reported PF. In future studies, it would be interesting to analyze the relationship between the 6MWTD and HRQOL changes following weight loss intervention and exercise training.

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Conflict of interest: The authors have no conflict of interest to declare.

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Notice:
This article was changed according to the erratum on January 11th 2016.

Erratum:
An **Author** was been omitted. The correct order is:
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