Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

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Body composition in relation to self-reported and device-measured physical activity in the HUNT4 survey

Master's thesis in Physical Activity, Health and Movement Science
Supervisor: Tom Ivar Lund Nilsen
Co-supervisor: Marius Steiro Fimland
June 2023

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Finally, I dedicate this project to my husband, Michael Onyema Okoro and our son, Chimdalu David Okoro. They are my world and very special to me.

ABSTRACT

Background

Body composition measures are important because it is known to be associated with the development of several chronic diseases. Describing the distribution of objectively measured body composition in the general population, and if this is related to different physical activity levels, may help to identify subgroups of the population that will benefit from lifestyle interventions.

Purpose

The aim of this study is to describe the variations in body composition measures according to self-reported and device measured physical activity and to assess if adverse body composition levels are associated with physical activity in the population-based HUNT Study.

Method

This study utilized HUNT4 data obtained between 2017-2019. The participants that gave information about self-reported physical activity using HUNT-4 questionnaire 1 were 54527, and 26003 participants had device-measured physical activity up to a week. InBody bioelectrical impedance was used for measuring body composition. Both self-reported and device measured physical activity were divided into three groups: <90 mins, 90-149 mins, and 150+ mins. Linear regression was used to estimate the age and sex adjusted mean difference in body composition measures related to self-reported and device measured physical activity measurements whereas logistic regression was used to estimate the age and sex adjusted odds ratio of adverse body composition levels associated with physical activity. All data were analysed using Stata.

Results

The study found that for device measured physical activity, all the body composition indices were lowest at the highest physical activity level of 150+ mins and highest at the least physical activity level of <90 mins for the linear regression, although the difference in mean was small for skeletal muscle mass, soft lean mass, and fat free mass. For example, the mean difference (with CI) of the body composition from the least to the most active participants decreased by 2.84 (-3.00 to -2.67) for body mass index and 0.33 (-0.56 to -0.09) for soft lean mass. However, for self-report, increased physical activity from <90 mins to 150+ mins was associated with lower body mass index, waist hip ratio, waist circumference, percent body fat, body fat mass,

visceral fat level, and visceral fat area and higher soft lean mass, skeletal muscle mass, and fat free mass. In addition, logistic regression showed that for both self-report and device measured physical activity, increased physical activity from the reference group of <90 mins to 150+ mins was associated with a reduced likelihood of adverse body composition levels, body mass index, waist circumference, waist hip ratio, and percent body fat.

Conclusion

There was an association between increased physical activity and lower levels of all body composition variables for device measured physical activity. For self-report, increased physical activity was associated with reduced body mass index, waist hip ratio, waist circumference, percent body fat, body fat mass, visceral fat area, and visceral fat level and increased fat free mass, soft lean mass, and skeletal muscle mass. Moreover, the proportion with adverse body mass index, waist hip ratio, percent body fat, and waist circumference decreased when physical activity increased from <90 mins to 150 mins.

INFOGRAPHIC

BODY COMPOSITION IN RELATION TO SELF-REPORTED AND DEVICE-MEASURED PHYSICAL ACTIVITY IN THE HUNT4 SURVEY

BACKGROUND

Body composition is associated with the development of chronic diseases → Physical activity modulates body composition to improve health

How does body composition indices vary with different physical activity categories?

Research Aim

- Variations in body composition measure according to self-report and device-measured physical activity.
- Variations in adverse body composition levels with respect to physical activity levels

Population-based study

METHOD

Design

Cross-sectional study

Hunt4 Data

2017 - 2019

Participants

54,527 SELF-REPORT
26, 003 DEVICE-MEASURED

Variables

Body Composition

Body mass index
Waist circumference
Waist hip ratio
Skeletal muscle mass
Soft lean mass
Fat free mass
Body fat mass
Percent body fat
Visceral fat area
visceral fat level

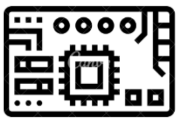
Physical activity

Category 1	<90 mins
Category 2	90-149 mins
Category 3	150+ mins

Instruments

Physical activity

Self-report
(HUNT4 Questionnaire 1)



Device (Axivity (AX3)
accelerometer)

Body composition

Bioelectrical impedance
(Inbody 770)

Data analysis

Linear Regression
Logistic Regression

Stata

RESULTS

Linear Regression

	<90 mins	90-149 mins	150+ mins
Device: Body fat mass, Percent body fat, Visceral fat area, visceral fat level, Body mass index, Waist circumference, Waist hip ratio, Fat free mass, Soft lean mass, Skeletal muscle mass	0	↓	↓
Self-report: Body fat mass, Percent body fat, Visceral fat area, visceral fat level, Body mass index, Waist circumference, Waist hip ratio	0	↓	↓
Fat free mass, Soft lean mass, Skeletal muscle mass	0	↑	↑

Logistic Regression (Adverse body composition levels)

Self-report & Device	<90 mins	90-149 mins	150+ mins
Percent body fat, Body mass index, Waist circumference, Waist hip ratio	1	↓	↓

CONCLUSION

- Body composition improves with increased physical activity levels.
- Body composition levels are more favorable among individuals that meet the recommended physical activity levels than less active individuals.

References Canva design graphics
https://inbody.no/?gclid=Cj0KCQjw7aqkBhDPARIsAKGa0oKvfz-y_ssgUMif94-LF8aHGRI9ng6YifHp5i7SslXyXOGjfC0Ak4oaArbZEALw_wcB5

1. INTRODUCTION

Body composition is significant to health because its abnormal levels in the body is known to be associated with the development of various diseases (Kuriyan, 2018; Minn & Suk, 2017). For example, excess visceral fat has been found to cause the release of fatty acids into the portal vein resulting in hepatic fat (De Souza et al., 2012). Moreover, high waist circumference, fat mass, and fat percentage are related to central obesity (Kallings et al., 2009), excess body fat in the presence of excess visceral adiposity is associated with insulin resistance, type 2 diabetes mellitus, hypertension, dyslipidaemia, and cardiovascular disease (Piché et al., 2018), low skeletal muscle mass is associated with stroke (Minn & Suk, 2017), and lean mass is used for assessing muscle depletion (Bosy-Westphal & Müller, 2015).

Computed tomography and magnetic resonance imaging are considered as the gold standard for body composition analysis, but they are not suitable for research and clinical use because they are expensive, require highly trained personnel for their use, and causes exposure to radiation (Cruz-Jentoft et al., 2019; Thomas et al., 2013). Bioelectrical impedance analysis (BIA) however is extensively used in studies because it is non-invasive, easy to use, inexpensive, has high processing speed, provides safe data, and does not emit radiation (Mialich et al., 2014; Böhm & Heitmann, 2013).

Physical activity modulates body composition (Zaccagni et al., 2014). Physical activity comprises of four components frequency, intensity, duration, and type (Barisic et al., 2011), and it can be measured using doubly labelled water, behavioural observation, questionnaires (self-report), and physiological markers (using heart rate monitors, calorimetry, and motion sensors such as the accelerometers) (Westerterp, 2009). In clinical and epidemiological research, accelerometers are the most used objective method while questionnaires are the most used subjective method.

The current physical activity guidelines recommend that adults engage in 150-300 min/week of moderate intensity or 75-150 min/week vigorous aerobic physical activity, with many epidemiological studies showing that this level of activity offers significant health benefits such as reducing the risk of cardiovascular diseases and metabolic syndrome and the risk of premature death while increasing muscle mass, strength, and quality (Lee et al., 2018; WHO, 2022; Hansen et al., 2019; Zaccagni et al., 2014). It could be that moderate and vigorous intensity of physical activity require more energy than low intensity physical activity or no activity, which could result in high breakdown of fats and increased muscle fibres and contractility and bone density, resulting in increased fat free mass and lean mass.

Various device and self-report studies have established an association between physical activity and body composition (Sedumedi et al., 2021; Zaccagni et al., 2014; Aars et al., 2019) and have shown that engaging in regular physical activity of recommended level was associated with reduced adiposity such as fat mass and fat mass index and increased fat free mass and lean mass index. Studies have also shown that moderate or vigorous physical activity below the recommended level such as 90 mins and below may be beneficial, even for individuals with the risk of cardiovascular disease and type 2 diabetes mellitus (Pang Wen et al., 2011; Sigal et al., 2006; Gill et al., 2023). Moreover, studies have compared device with self-report measurement of physical activity in relation to body composition (Sabia et al., 2015; Guo et al., 2019), and it was found that device measurement was more related to body composition than self-report. However, there is dearth of knowledge concerning how different body composition indices vary with different levels of physical activity, and there is not enough evidence about the relationship between these physical activity levels and adverse body composition levels.

Therefore, the overall aim of this study was to describe the variations in body composition measures according to different categories of self-reported and device-measured physical activity in a population-based HUNT Study, and the secondary aim was to determine the variations of adverse body composition levels in relation to physical activity levels. The findings of this study would be useful as a reference data on body composition from a population-based study and in determining if this is related to different physical activity level. This may help in identifying subgroups of the population that will benefit from lifestyle interventions. It would also be helpful in identifying if physical activity below the recommended level could be beneficial in improving body composition.

2. METHOD

2.1 Study design

This is a cross-sectional study utilizing data from the HUNT4 survey of the Trøndelag Health Study (HUNT) obtained between year 2017-2019.

2.2 HUNT4 study

The HUNT4 study is the fourth data collection wave of the HUNT study conducted between 2017 to 2019, and one of the world largest population-based studies. Some of the reasons for the HUNT4 survey were to follow up on the previous participants and the new inhabitants of the region and to utilize improved measurement methods on various important health and lifestyle characteristics (Åsvold et al., 2022). The new research areas in the HUNT4 study included physical activity utilizing accelerometer recordings and body composition measurements utilizing bioelectrical impedance, and the study was conducted by trained health professionals in each of the 23 municipalities in Nord-Trøndelag. (Åsvold et al., 2022).

2.3 Participants

There were 56041 Norwegian men and women from 19 years and above that participated in the HUNT4 Nord-Trøndelag Health Study, and while 54527 participants gave information on the self-report (questionnaire) physical activity level, 26003 participants provided information on the device-measured (sensor) physical activity level.

2.4 Variables

2.4.1 Body composition variables

The present study included relevant body composition variables from the HUNT4-Nord Trøndelag study, which were body mass index, waist hip ratio, waist circumference, body fat mass, percent body fat, skeletal muscle mass, soft lean mass, visceral fat area, visceral fat level, and fat-free mass. Body composition variables were measured with InBody bioelectrical impedance (InBody 770) analysis (HUNT databank). Fat free mass consists of bone mass, muscle mass, vital organs, and extracellular fluid, body fat mass is the total amount of fat from fat cells and other cells and was calculated by deducting fat-free mass from body weight, soft lean mass was calculated by subtracting the bone minerals from fat-free mass. Participants with pacemakers did not complete the full body scan with the Inbody because of the electrical impulses (HUNT databank). Abnormal values due to measurement error were deleted by the HUNT administration before data delivery. The cut off values for adverse body composition levels are body mass index = >30 kg/m^2 (WHO, 2010), waist circumference = >102/88 cm (for male and female respectively) (WHO, 2008), percent body fat = >25/35% (for male and female respectively) (Li et al., 2012, Chen et al., 2021), and waist hip ratio = >0.9/0.85 (for male and female respectively) (WHO 2008).

2.4.2 Physical activity variables

The study included both self-reported and device-measured physical activity variables. The self-reported physical activity was taken using HUNT4 questionnaire 1 (HUNT databank), and the variables obtained were frequency, intensity, and duration of activity. The responses on frequency of physical activity were 'Never, Less than once a week, Once a week, 2-3 times a week, and Nearly every day', responses on the intensity of physical activity included 'I take it easy and I don't get out of breath or break a sweat, I push myself until I'm out of breath or break into a sweat, and I practically exhaust myself', and responses on duration of activity included 'less than 15 minutes, 15-29 minutes, 30-60 minutes, and more than 1 hour' (HUNT databank). From the data, the frequency of 0 was assigned to 'less than once a week', 1 for once a week, 2.5 for 2-3 times a week, and 5 for nearly every day, and for the duration in minutes per day, an average of 10 minutes was given to less than 15 minutes, 22.5 minutes to 15-29 minutes, 45 minutes to 30-60 minutes, and 60 minutes to more than 1 hour. The total duration of physical activity per week was obtained by multiplying the frequency of activity per week by the duration of activity per day. Based on the participants' physical activity levels, the duration of physical activity per week was categorized into 3 groups: less than 90 mins (<90 mins), 90-149 mins, and 150 mins and above (150+ mins). Physical activity level of 150+ mins represents the recommended duration of moderate activity per week.

For device-measured physical activity, accelerometers (AX3, Axivity Ltd., Newcastle, UK) were utilized (Åsvold et al., 2022). The participants wore the accelerometers on the thigh and lower back between 3 to 7 days, and information about the total number of minutes of physical activity per week was recorded and obtained from the device. The recordings obtained from the accelerometer were activity duration in minutes per week and frequency per day. Like the self-report, the number of minutes of activity spent per week was categorized into 3 groups: <90 mins, 90-149 mins, and 150+ mins. For both instruments, the intensity of activity was not considered for better comparison since only the questionnaire gave information about the activity intensity and not the device.

2.4.3 Other variables

Other variables included age (years), gender (male/female), level of education, and smoking history. Asides age and gender, these variables were used only to describe the sample, and not in the statistical analysis as confounders.

2.5 Selection criteria

The present study included HUNT 4 study participants from 19 years and above with data on objective and/or subjective measured physical activity as well as body composition.

2.6 Ethical considerations

HUNT data was released by HUNT after the study was approved by the medical and research ethical committee (REC). All the data were stored and analysed using NTNU's secure server, NTNU NICE. This was to ensure confidentiality of the data and protection of participants' privacy. Moreover, since this study did not involve direct contact with the participants, there was no risk to the participants.

2.7 Statistical analysis

The descriptive statistics of the participants' characteristics based on self-report and device-measured physical activity was determined. Linear regression was used to estimate the mean differences and variations in body composition measures according to self-report and device-measured physical activity levels. Category <90 mins has a mean difference of 0.00 for all the body composition measures because it is the reference group. Further, logistic regression was used to estimate the odds ratio (OR) for adverse body mass index, waist circumference, waist hip ratio, and percent body fat levels according to device-measured and self-report physical activity. Category <90 mins has odds ratio of 1.00 for the body composition variables because it is also the reference group. All associations were adjusted for age (range of 10 years interval) and sex (man, woman). The precision of all associations was assessed by a 95% confidence interval (CI). All data were analysed using Stata.

3. RESULTS

Table 1 shows descriptive statistics according to self-reported and device-measured physical activity levels: number of participants, age, gender, education level, and smoking status. There were 54527 participants for self-reported physical activity and 26003 participants for device-measured physical activity.

Table 1. Descriptive statistics according to self-reported and device-measured physical activity levels

Characteristics	PA-self-report (n= 54527)			PA-device-measured (n=26003)		
	<90 mins	90-149 mins	150+ mins	<90 mins	90-149 mins	150+ mins
No. of participants (%)	23826 (43.7)	15927 (29.2)	14774 (27.1)	7457 (28.7)	14009 (53.9)	4537 (17.5)
Mean age (SD), years	54.3 (18.1)	54.5 (16.6)	54.3 (17.2)	58.5 (19.2)	52.6 (15.7)	51.9 (13.7)
Percent female	50.6	60.6	53.9	59.8	58.0	47.0
Percent high education	32.0	44.8	45.4	36.8	47.2	42.9
Percent daily smoking	12.2	5.8	5.1	10.4	6.5	4.4

For self-report, most of the participants (43.7%) engaged in physical activity <90 mins, and the mean age of participants in the 3 categories is approximately the same. Moreover, group 90-149 mins has the most female participants. In addition, a smaller proportion of participants in the least physical activity group reported high education, whereas a larger proportion of participants in the least active group were smokers.

For device-measured physical activity, most of the participants (53.87%) engaged in physical activity level 90-149 mins, and the least active (<90 mins) participants are a bit older. Moreover, the most active group (150+ mins) has the least proportion of female participants and a smaller proportion of participants in the lowest physical activity category reported high education. Further, the least active group has the highest proportion of smokers while the most active has the least proportion of smokers.

Table 2 – Mean levels of body composition measures according to device measured physical activity level (n = 26,003) (Linear regression)

	PA-device time per week		
	<90 mins	**90-149 mins**	**150+ mins**
Body mass index (kg/m^2)			
N	7428	13980	4524
Mean (SD)	28.20 (5.16)	26.67 (4.22)	25.92 (3.75)
Mean difference (95% CI)	0.00	-1.52 (-1.65 to -1.40)	-2.28 (-2.45 to -2.12)
Adjusted[a] mean difference (95% CI)	0.00	-1.84 (-1.97 to -1.71)	-2.84 (-3.00 to -2.67)
Waist Hip Ratio			
N	7222	13922	4510
Mean (SD)	0.98 (0.09)	0.94 (0.08)	0.92 (0.08)
Mean difference (95% CI)	0.00	-0.03 (-0.04 to -0.03)	-0.06 (-0.06 to -0.05)
Adjusted[a] mean difference (95% CI)	0.00	-0.04 (-0.037 to -0.035)	-0.063 (-0.066 to -0.060)
Waist circumference (cm)			
N	7224	13922	4150
Mean (SD)	100.42 (15.15)	95.32 (13.16)	92.39 (12.31)
Mean difference (95% CI)	0.00	-5.08 (-5.47 to -4.69)	-8.01 (-8.52 to -7.51)
Adjusted[a] mean difference (95% CI)	0.00	-6.21 (-6.59 to -5.82)	-10.26 (-10.76 to -9.76)
Soft lean mass (kg)			
N	6999	13783	4491
Mean (SD)	50.21 (10.56)	51.47 (10.66)	53.60 (10.77)
Mean difference (95% CI)	0.00	1.26 (0.95 to 1.56)	3.39 (2.99 to 3.79)
Adjusted[a] mean difference (95% CI)	0.00	-0.19 (-0.37 to -0.01)	-0.33 (-0.56 to -0.09)
Percent body fat (%)			
N	6998	13783	4491
Mean (SD)	34.27 (9.28)	30.10 (8.76)	26.50 (8.42)
Mean difference (95% CI)	0.00	-4.17 (-4.42 to -3.91)	-7.76 (-8.09 to -7.43)
Adjusted[a] mean difference (95% CI)	0.00	-3.77 (-3.99 to -3.56)	-6.39 (-6.67 to -6.11)
Body fat mass (kg)			
N	6999	13783	4491
Mean (SD)	28.65 (11.42)	23.98 (9.48)	20.80 (8.46)
Mean difference (95% CI)	0.00	-4.67 (-4.95 to -4.38)	-7.85 (-8.22 to -7.48)
Adjusted[a] mean difference (95% CI)	0.00	-4.96 (-5.24 to -4.67)	-8.03 (-8.40 to -7.66)
Skeletal muscle mass (kg)			
N	6999	13783	4491
Mean (SD)	29.40 (6.71)	30.33 (6.78)	31.72 (6.85)
Mean difference (95% CI)	0.00	0.94 (0.74 to 1.13)	2.32 (2.07 to 2.58)
Adjusted[a] mean difference (95% CI)	0.00	-0.06 (-0.17 to 0.05)	-0.13 (-0.28 to 0.02)
Visceral fat area (cm^2)			
N	6999	13783	4491
Mean (SD)	142.39 (58.37)	115.06 (49.94)	97.50 (43.61)
Mean difference (95% CI)	0.00	-27.32 (-28.80 to -25.84)	-44.89 (-46.81 to -42.96)
Adjusted[a] mean difference (95% CI)	0.00	-27.06 (-28.51 to -25.61)	-43.18 (-45.07 to -41.28)
Visceral fat level			
N	6999	13783	4491
Mean (SD)	13.74 (5.85)	11.01 (5.00)	9.25 (4.37)
Mean difference (95% CI)	0.00	-2.73 (-2.88 to -2.58)	-4.49 (-4.68 to -4.30)
Adjusted[a] mean difference (95% CI)	0.00	-2.71 (-2.85 to -2.56)	-4.32 (-4.51 to -4.13)
Fat free Mass (kg)			
N	6999	13783	4491
Mean (SD)	53.31 (11.16)	54.65 (11.28)	56.90 (11.39)
Mean difference (95% CI)	0.00	1.34 (1.02 to 1.67)	3.59 (3.17 to 4.01)
Adjusted[a] mean difference (95% CI)	0.00	-0.18 (-0.37 to 0.01)	-0.33 (-0.58 to -0.08)

[a]Adjusted for age (10-year categories) and sex (men, women) SD = standard deviation, CI = confidence interval, PA = physical activity

Table 2 shows the mean values with standard deviation, mean difference, and adjusted mean difference of body composition according to device-measured physical activity level per week with 95% confidence interval (CI) using linear regression.

In the linear regression adjusted for age and sex, the mean of all the body composition indices decreased at the highest physical activity level (150+ mins) compared to the least physical activity level (<90 mins i.e., reference group), although the magnitude of the decrease is high with variables related to adiposity. The most active participants have the least level of these body composition variables while the least active participants have the highest level of these body composition variables. The mean difference (with CI) of the body composition from the reference group (<90 mins) to the most active participants (150+ mins) decreased by 2.84 (-3.00 to -2.67) for body mass index, 0.063 (-0.066 to -0.060) for waist hip ratio, 10.26 (-10.76 to -9.76) for waist circumference, 0.33 (-0.56 to -0.09) for soft lean mass, 6.39 (-6.67 to -6.11) for percent body fat, 8.03 (-8.40 to -7.66) for body fat mass, 0.13 (-0.28 to 0.02) for skeletal muscle mass, 43.18 (-45.07 to -41.28) for visceral fat area, 4.32 (-4.51 to -4.13) for visceral fat level, and 0.33 (-0.58 to -0.08) for fat free mass.

The mean difference and CIs were negative, indicating that increased physical activity is associated with lower levels of these body composition variables. However, for skeletal muscle mass, soft lean mass, and fat free mass, the magnitude of the association was small because there was no clear difference in means between the least active group (<90 mins) and the most active group (150+ mins) since the mean difference is very small compared to that of other body composition variables.

Table 3 – Mean levels of body composition measures according to self-report physical activity level (n = 54,527) (Linear regression)

	PA-self-report time per week		
	<90 mins	**90-149 mins**	**150+ mins**
Body mass index (kg/m^2)			
N	22864	15541	14343
Mean (SD)	28.07 (5.11)	27.05 (4.50)	26.12 (4.05)
Mean difference (95% CI)	0.00	-1.01 (-1.11 to -0.92)	-1.94 (-2.04 to -1.84)
Adjusted[a] mean difference (95% CI)	0.00	-1.06 (-1.15 to -0.97)	-1.99 (-2.09 to -1.90)
Waist circumference (cm)			
N	21945	15225	14124
Mean (SD)	100.42 (15.12)	96.33 (13.52)	93.09 (12.85)
Mean difference (95% CI)	0.00	-4.08 (-4.37 to -3.79)	-7.33 (-7.63 to -7.03)
Adjusted[a] mean difference (95% CI)	0.00	-3.85 (-4.13 to -3.57)	-7.39 (-7.68 to -7.11)
Waist hip ratio			
N	21931	15224	14123
Mean (SD)	0.98 (0.09)	0.95 (0.08)	0.93 (0.08)
Mean difference (95% CI)	0.00	-0.026 (-0.028 to -0.024)	-0.048 (-0.050 to -0.047)
Adjusted[a] mean difference (95% CI)	0.00	-0.027 (-0.028 to -0.025)	-0.05 (-0.052 to -0.049)
Soft lean mass (kg)			
N	21256	14916	13884
Mean (SD)	52.36 (11.31)	50.66 (10.44)	51.80 (10.74)
Mean difference (95% CI)	0.00	-1.69 (-1.92 to -1.47)	-0.56 (-0.79 to -0.32)
Adjusted[a] mean difference (95% CI)	0.00	0.24 (0.11 to 0.37)	0.34 (0.20 to 0.47)
Body fat mass (kg)			
N	21256	14916	13884
Mean (SD)	27.33 (11.43)	25.24 (10.10)	22.25 (9.26)
Mean difference (95% CI)	0.00	-2.09 (-2.31 to -1.87)	-5.08 (-5.30 to -4.86)
Adjusted[a] mean difference (95% CI)	0.00	-2.75 (-2.96 to -2.54)	-5.45 (-5.67 to -5.23)
Percent body fat (%)			
N	21255	14915	13884
Mean (SD)	32.36 (9.55)	31.45 (9.03)	28.43 (9.05)
Mean difference (95% CI)	0.00	-0.91 (-1.11 to -0.72)	-3.93 (-4.13 to -3.73)
Adjusted[a] mean difference (95% CI)	0.00	-2.25 (-2.41 to -2.09)	-4.61 (-4.77 to -4.44)
Skeletal muscle mass (kg)			
N	21256	14916	13884
Mean (SD)	30.84 (7.20)	29.78 (6.64)	30.54 (6.85)
Mean difference (95% CI)	0.00	-1.06 (-1.20 to -0.91)	-0.30 (-0.45 to -0.16)
Adjusted[a] mean difference (95% CI)	0.00	0.19 (0.10 to 0.27)	0.28 (0.20 to 0.37)
Visceral fat level			
N	21256	14916	13884
Mean (SD)	12.90 (5.84)	11.74 (5.31)	10.11 (4.90)
Mean difference (95% CI)	0.00	-1.16 (-1.27 to -1.04)	-2.79 (-2.90 to -2.68)
Adjusted[a] mean difference (95% CI)	0.00	-1.58 (-1.69 to -1.48)	-3.05 (-3.16 to -2.94)
Visceral fat area (cm^2)			
N	21256	14916	13884
Mean (SD)	133.94 (58.28)	122.38 (52.95)	106.04 (48.95)
Mean difference (95% CI)	0.00	-11.56 (-12.70 to -10.42)	-27.91 (-29.07 to -26.75)
Adjusted[a] mean difference (95% CI)	0.00	-15.81 (-16.88 to -14.73)	-30.47 (-31.56 to -29.37)
Fat free mass (kg)			
N	21256	14916	13884
Mean (SD)	55.55 (11.95)	53.80 (11.05)	55.01 (11.36)
Mean difference (95% CI)	0.00	-1.75 (-2.00 to -1.51)	-0.54 (-0.78 to -0.29)
Adjusted[a] mean difference (95% CI)	0.00	0.29 (0.15 to 0.43)	0.41 (0.26 to 0.55)

[a]Adjusted for age (10-year categories) and sex (men, women), SD = standard deviation, CI = confidence interval, PA = physical activity

Table 3 shows the mean values with standard deviation, mean difference, and adjusted mean difference of body composition according to self-report physical activity level per week at 95% confidence interval using linear regression model.

In the linear regression models adjusted for age and sex, there is a decrease in the mean difference for body mass index, waist hip ratio, waist circumference, percentage body fat, body fat mass, visceral fat level, and visceral fat area with increased physical activity level from the least active group (reference group of <90 mins) to the highest active group, with the mean difference and CIs indicating that increased in physical activity is associated with lower levels of these body composition variables. The mean difference (with CI) of the body composition from the reference group to the most active participants decreased by 1.99 (-2.09 to -1.90) for body mass index, 0.05 (-0.052 to -0.049) for waist hip ratio, 7.39 (-7.68 to -7.11) for waist circumference, 4.61 (-4.77 to -4.44) for percent body fat, 5.45 (-5.67 to -5.23) for body fat mass, 30.47 (-31.56 to -29.37) for visceral fat area, and 3.05 (-3.16 to -2.94) for visceral fat level.

However, there is an increase in mean difference for soft lean mass, skeletal muscle mass, and fat free mass from <90 mins to 150+ mins activity level with the mean difference and CIs indicating that increased physical activity level is associated with higher levels of these body composition variables. The mean difference (with CI) of the body composition from the least active participants to the most active participants increased by 0.34 (0.20 to 0.47) for soft lean mass, 0.28 (0.20 to 0.37) for skeletal muscle mass, and 0.41 (0.26 to 0.55) for fat free mass.

That is, increased physical activity is associated with lower body mass index, waist hip ratio, waist circumference, percentage body fat, body fat mass, visceral fat level, and visceral fat area and higher soft lean mass, skeletal muscle mass, and fat free mass.

Table 4 – Odds ratio for adverse body composition levels according to self-report physical activity levels (logistic regression)

Characteristics	PA-Self-report time per week		
	<90 mins	**90-149 mins**	**150+ mins**
Body mass index>30			
No. of persons	22864	15541	14343
No. of cases	7108	3476	2243
Crude OR	1.00	0.64	0.41
Adjusted OR[a] (95% CI)	1.00	0.61 (0.58 to 0.64)	0.40 (0.37 to 0.42)
Waist circumference>102/88			
No. of persons	21945	15225	14124
No of cases	12744	7830	5617
Crude OR	1.00	0.76	0.48
Adjusted OR[a] (95% CI)	1.00	0.63 (0.60 to 0.66)	0.40 (0.38 to 0.42)
Percent body fat>25/35			
No. of persons	21255	14915	13884
No of cases	12218	7156	5074
Crude OR	1.00	0.68	0.43
Adjusted OR[a] (95% CI)	1.00	0.62 (0.59 to 0.65)	0.37 (0.36 to 0.39)
Waist hip ratio>0.9/0.85			
No. of persons	21931	15224	14123
No of cases	18936	12494	10225
Crude OR	1.00	0.72	0.41
Adjusted OR[a] (95% CI)	1.00	0.59 (0.55 to 0.62)	0.35 (0.33 to 0.37)

[a]Adjusted for age (10-year categories) and sex (men, women), OR = odd ratio

Table 4 shows the logistic regression for adverse body composition levels according to self-report physical activity with odds ratio at 95% CI. The cutoff values of >102/88 cm for waist circumference, >25/35% for percent body fat, and >0.9/0.85 for waist hip ratio were for male and female respectively. In the logistic regression model adjusted for age and sex, there is a decrease in odds ratio from the least activity level (reference group of <90 mins) to the highest activity level (150+ mins) for adverse body mass index, waist hip ratio, percent body fat, and waist circumference. The odds ratio (with CI) of the body composition from the least active participants to the most active participants decreased from 1 to 0.40 (0.37 to 0.42) for body mass index, 0.40 (0.38 to 0.42) for waist circumference, 0.37 (0.36 to 0.39) for percent body fat, and 0.35 (0.33 to 0.37) for waist hip ratio. The odds ratio (with CIs) indicate that increased physical activity is associated with a reduced likelihood of adverse body composition levels, compared to the reference group of <90 mins.

Table 5 – Odds ratio for adverse body composition levels according to device measured physical activity levels (logistic regression)

Characteristics	**PA-Device**		
	<90 mins	**90-149 mins**	**150+ mins**
Body mass index>30			
No of persons	7428	13980	4524
No of cases	2420	2677	624
Crude OR	1.00	0.49	0.33
Adjusted OR[a] (95% CI)	1.00	0.42 (0.39 to 0.45)	0.27 (0.24 to 0.29)
Waist circumference>102/88			
No. of persons	7224	13922	4510
No of cases	4499	6622	1521
Crude OR	1.00	0.56	0.31
Adjusted OR[a] (95% CI)	1.00	0.48 (0.45 to 0.51)	0.27 (0.25 to 0.29)
Percent body fat>25/35			
No. of persons	6998	13783	4491
No of cases	4499	5815	1272
Crude OR	1.00	0.41	0.22
Adjusted OR[a] (95% CI)	1.00	0.41 (0.39 to 0.44)	0.22 (0.20 to 0.24)
Waist hip ratio>0.9/0.85			
No. of persons	7222	13922	4510
No of cases	6325	11112	3093
Crude OR	1.00	0.56	0.31
Adjusted OR[a] (95% CI)	1.00	0.53 (0.48 to 0.58)	0.30 (0.27 to 0.33)

[a]Adjusted for age (10-year categories) and sex (men, women), OR = odds ratio

Table 5 shows the logistic regression model for adverse body composition levels according to device measured physical activity with odds ratio at 95% CI. Like the self-report, the odds ratio decreased from the least activity level (reference group of <90 mins) to the highest level (150+ mins) for adverse body mass index, waist hip ratio, percent body fat, and waist circumference. The odds ratio (with CI) of the body composition from the least active participants to the most active participants decreased from 1 to 0.27 (0.24 to 0.29) for body mass index, 0.27 (0.25 to 0.29) for waist circumference, 0.22 (0.20 to 0.24) for percent body fat, and 0.30 (0.27 to 0.33) for waist hip ratio. The odds ratio (with CIs) indicate that increased physical activity is associated with a reduced likelihood of adverse body composition levels, compared to the reference group of <90 mins.

4. DISCUSSION

4.1 Main findings

The main aim of the present study was to describe the variations in body composition measures according to self-report and device measured physical activity levels, and the secondary aim was to determine the variations in adverse levels of body composition with respect to self-report and device-measured physical activity levels. The study showed that for device measured physical activity, increased physical activity from the least to the highest level was associated with lower levels of all body composition variable, while for self-reported physical activity, increased physical activity was associated with lower body mass index, waist hip ratio, waist circumference, percentage body fat, body fat mass, visceral fat level, and visceral fat area and higher soft lean mass, skeletal muscle mass, and fat free mass. Moreover, it was also found that for both self-report and device, increased physical activity level is likely to reduce adverse body mass index, waist circumference, waist hip ratio, and percent body fat. This means that the higher the physical activity level, the likelihood of the adverse body composition levels being lowered.

4.2 The variations in body composition measures according to device and self-report physical activity level measurements

According to the adjusted linear regression for device and self-report physical activity measurements, it was found that increased physical activity level from <90 mins to 150+ mins was associated with lower values of body mass index, waist hip ratio, waist circumference, percent body fat, body fat mass, visceral fat area, and visceral fat level respectively. This indicates a negative relationship between increased physical activity levels and these body composition variables. This means that higher physical activity level is associated with or related to lower adiposity. Although association does not mean causality, it could be inferred from this finding that the higher the physical activity level, the lower the risks of cardiometabolic diseases and vice versa. An updated report of the 1995 Centers for Disease Control (CDC)/American College of Sports Medicine (ACSM) by Haskell et al., 2007 stated that there is a dose-response association between physical activity and health, and to decrease the risk for chronic diseases or unhealthy weight gain, exceeding the minimum recommended amounts of physical activity is vital. The minimum recommended dose is 30 min per day on 5 day per week of moderate intensity or 20 min per day on 3 day per week of vigorous intensity or a combination of both, which is similar to WHO recommendation (WHO, 2022) of 150 mins moderate intensity of physical activity level or 75 mins vigorous intensity activity level per week for adults. However, performing physical activity below this level could also be beneficial to human health in mitigating the incidence of chronic diseases, which is reflected in the changes in the mean values of the body composition variables with the physical activity categories below 150+ mins in the present study. This is corroborated by the findings of a prospective cohort study by Pang Wen et al., 2011, whereby participants that had low-volume activity of 92 mins per week had 14% reduced risk of all-cause mortality and three years longer life expectancy compared to those who did not exercise at all. It was also stated in the study that every increase in daily exercise by 15 mins more than the minimum amount of 92 mins per week reduced further all-cause mortality by 4% and all-cancer mortality by 1%. Therefore, it is best to follow the recommended physical activity level for optimum health benefits but engaging in physical activity below this level is beneficial and better than not engaging at all.

On the other hand, the present study found that higher physical activity level was significantly associated with higher soft lean mass, skeletal muscle mass, and fat free mass for self-report but for the device, increasing physical activity level was associated with lower soft lean mass, skeletal muscle mass, and fat free mass although the magnitude of the association was small because there was no clear difference in means between the least active group and the most active group since the mean difference was very small. Nevertheless, previous questionnaire and accelerometer studies on different age groups have shown that higher engagement in physical activities was associated with higher values of muscle mass, lean soft tissue mass, and fat free mass (Hong-Wen et al., 2001; Raguso et al., 2006; Hao et al., 2019; Córdoba-Rodríguez et al., 2022). Likewise, Morishita et al., 2014 found that vigorous and moderate intensity of physical activity for haemodialysis patients were positively associated with skeletal muscle mass after adjustment for age, sex, and haemodialysis duration. The reason for the increase in the level of fat free mass has been attributed to the increase in the potassium components of fat free mass with increased physical activity levels (Hansen & Allen, 2002). In addition, studies on older population have also found that engaging in physical activity improved muscle mass, strength, and quality, thus preventing sarcopenia (Lee et al., 2018; Park et al., 2010). The discrepancy between the previous findings and the findings of the present study could be because in the present study, the type and intensity of activity was not available for the accelerometer unlike the previous studies whereby the physical activities considered were of known intensities, which could have increased muscle mass, soft lean mass, and fat free mass. In the present study, while the questionnaire captured exercise during leisure time activity and not all activity of daily living nor work-related activity, the device-based measurements may have included total physical activity including work related activity. It could also be speculated that the participants that wore the device did not engage in resistance training (which impacts muscle mass much more than other activities) or high/moderate intensity activity unlike self-reported participants.

4.3 The variations in adverse level of body composition according to device-measured and self-report physical activity level

The relationship between self-reported and device-measured physical activity level and the adverse levels of body composition variables such as body mass index, waist circumference, percent body fat, and waist hip ratio was determined using logistic regression model in tables 4 and 5 respectively. The reason for the selected body composition variables was because their cut-off values are known (WHO, 2010; WHO, 2008; Li et al., 2012; Chen et al., 2021). These selected body composition variables define overweight and obesity as well as predictors of cardiometabolic diseases (Huxley et al., 2010; Bener et al., 2013; Paniagua et al., 2008). In the present study, it was found from the adjusted model that both self-report and device-measured physical activity showed a significant negative association with adverse body composition values. In other words, the higher the physical activity level, the lower these adverse body composition levels. It can also be inferred that physical activity has the tendency to modulate adverse body composition levels, and this is in line with previous studies. Thorogood et al., 2011 conducted a systematic review and meta-analysis of randomized controlled trials that involved overweight and obese populations that engaged in combination of different exercise programs between 120 and 240 mins per week for 6 to 12 months and found that there was a reduction in weight and waist circumference among these populations due to physical activity, and Swift et al., 2014 stated in a review that overweight and obese adults that consistently engage in exercise program of public health recommendations can have weight loss of less than or approximately 2 kg. It is not conclusive the minimum physical activity duration that can reverse adverse body composition because the total length and the intensity of activity appear to be an important factor, which the public health recommendations and the present study respectively did not account for. However, from the findings of the present study, those with adverse body composition variables are likely to benefit most from physical activity level above 150 mins as this will reduce excess adiposity better than engaging in physical activity below 150 mins.

4.4 Strengths

To our knowledge, this is the first study to investigate if objectively assessed body composition measures vary according to different levels of self-reported and device-measured physical activity in a large population-based sample of more than 50 000 people and the first to include comprehensive body composition variables. This could be used for generalizability and a reference data for body composition values and physical activity levels, and in administering lifestyle intervention. The instruments: bioelectric impedance and Axivity 3 accelerometer (device) are valid and reliable for measuring body composition and physical activity respectively. Moreover, unlike other accelerometers used in previous studies, Axivity 3 device was worn on the thigh and lower back, measuring the activity of the upper and lower body.

4.5 Limitations

A limitation of this study is that some useful information such as activity type and intensity for the accelerometer were not included in the HUNT data, and this made the study consider only activity duration, which may not have given comprehensive information about the physical activity of the participants. Moreover, the questionnaire was designed to capture exercise in leisure time activity and not all activity of daily living. In addition, information about the validity of the self-reported physical activity HUNT4 questionnaire is not known. Further, this is a cross-sectional study design, which does not determine cause-effect relationship, therefore causal inference cannot be made.

4.6 Recommendation

This study can serve as basis for longitudinal study, whereby the body composition and the physical activity levels of the participants will be monitored for a long time, thus monitoring the overall health status of the population. Further studies utilizing this data to investigate if the association between physical activity and body composition depends on age and sex is also recommended. Therefore, the present study can be a base for further studies.

5. CONCLUSION

This study investigated the relationship between self-report and device-measured physical activity and body composition and the association between physical activity and adverse body composition levels. The study has found that there are changes in body composition with respect to the different physical activity levels from <90 mins to 150 mins+ and that the proportion with adverse body mass index, waist hip ratio, percent body fat, and waist circumference decreased when physical activity increased from <90 mins to 150 mins. There was an association between increased physical activity from <90 mins to 150+ mins and lower levels of all body composition variables for device measured physical activity, while for self-report, increased physical activity was associated with reduced body mass index, waist hip ratio, waist circumference, percent body fat, body fat mass, visceral fat area, and visceral fat level and increased fat free mass, soft lean mass, and skeletal muscle mass. Our results suggest that body composition levels are more favorable among persons who meet recommended levels of physical activity than those who are less active, and thus the activity level in the population may influence reference values for body composition measures.

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