DIFFERENCES OF PHYSICAL ACTIVITY BETWEEN SCREEN-DETECTED TYPE 2 DIABETICS, KNOWN TYPE 2 DIABETICS AND NON-DIABETICS

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Master's Thesis in Sports and Exercise Medicine

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Fall 2006

TIIVISTELMÄ

Fyysisen aktiivisuuden erot aikaisemmin tunnistamattomien tyypin 2 diabeetikoiden, aikaisemmin tunnistettujen tyypin 2 diabeetikoiden ja ei-diabeetikoiden välillä
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Liikuntalääketieteen pro gradu –tutkielma
19 sivua, 1 liite

Tutkimuksen tarkoituksena oli selvittää, eroaako aikaisemmin tunnistamattomien tyypin 2 diabeetikoiden fyysinen aktiivisuus aikaisemmin tunnistettujen tyypin 2 diabeetikoiden fyysisestä aktiivisuudesta. Tämän lisäksi tarkoituksena oli selvittää, missä fyysisen aktiivisuuden muodoissa aikaisemmin tunnistamattomat tyypin 2 diabeetikot eroavat ei-diabeetikoista. Aikaisemmin tunnistamattomilla tyypin 2 diabeetikoilla tarkoitetaan henkilöitä, joilla ei ollut diagnosoitua tyypin 2 diabetesta, mutta joiden plasman paastoglukoosiarvo oli väestötutkimuksen yhteydessä ≥ 7.0 mmol/l tai kahden tunnin glukoosiarvo oli ≥ 11.1 mmol/l.

Tutkimus on osa Dehkon 2D-hankkeen väestötutkimusta, jolla selvitetään lihavuuden, tyypin 2 diabeteksen ja muiden glukoosiaineenvaihduntahäiriöiden yleisyyttä Suomessa. Tutkimukseen, johon kuului kahden tunnin glukoosirasituskoe, kutsuttiin 4500 satunnaisotannalla poimittua 45-74 -vuotiasta miestä ja naista. Terveystarkastukseen osallistui 62% miehistä ja 67% naisista. Fyysinen aktiivisuus arvioitiin kyselyn avulla, ja tulokset analysoitiin logistisella ja lineaarisella regressio-analyysillä.

Naisilla aikaisemmin tunnistamattomat tyypin 2 diabeetikot olivat fyysisesti passiivisempia kuin aikaisemmin tunnistetut tyypin 2 diabeetikot. Tilastollisesti merkitseviä ikävakioituja eroja esiintyi liikuntakerran kestossa (P = 0.041) ja viikoittaisten kohtuukuormitteisten liikuntakertojen määrässä (P = 0.002). Samat erot olivat tilastollisesti merkitseviä myös aikaisemmin tunnistamattomien tyypin 2 diabeetikoiden ja ei-diabeetikoiden välillä (P = 0.014 ja 0.001) siten, että ei-diabeetikot olivat fyysisesti aktiivisempia. Tämän lisäksi vapaa-ajan fyysinen aktiivisuus oli merkitsevästi alhaisempaa aikaisemmin tunnistamattomilla tyypin 2 diabeetikoilla kuin ei-diabeetikoilla (P = 0.001).

Miehillä aikaisemmin tunnistamattomat tyypin 2 diabeetikot eivät eronneet fyysiseltä aktiivisuu-deltaan tilastollisesti merkitsevästi aikaisemmin tunnistetuista tyypin 2 diabeetikoista. Aikaisemmin tunnistamattomien tyypin 2 diabeetikoiden vapaa-ajan fyysinen aktiivisuus (P = 0.001), hyötyliikunta (P = 0.014) ja viikoittaisten liikuntakertojen määrä (P = 0.017) olivat tilastollisesti merkitsevästi alhaisempia verrattuna ei-diabeetikoihin.

Johtopäätöksenä voidaan todeta, että naisilla aikaisemmin tunnistamattomat tyypin 2 diabeetikot olivat fyysisesti passiivisempia kuin aikaisemmin tunnistetut tyypin 2 diabeetikot, mutta miehillä tätä eroa ei ollut nähtävissä. Ei-diabeetikot olivat fyysisesti aktiivisempia kuin aikaisemmin tunnistamattomat tyypin 2 diabeetikot molemmilla sukupuolilla. Näin ollen tutkimus tuki vallitsevaa näkemystä, jonka mukaan säännöllinen fyysinen aktiivisuus suojelee tyypin 2 diabeteksen kehittymiseltä, ja tutkimus antaa epäsuoraa näyttöä siitä, että naisilla tyypin 2 diabeteksen diagnosointi ja sitä seuraava liikuntaneuvonta johtaa toivottuun fyysisen aktiivisuuden lisäämiseen.

Asiasanat: fyysinen aktiivisuus, aikaisemmin tunnistamaton tyypin 2 diabetes, aikaisemmin tunnistettu tyypin 2 diabetes

ABSTRACT

Differences of physical activity between screen-detected type 2 diabetics, known type 2 diabetics and non-diabetics
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Master's Thesis in Sports and Exercise Medicine
19 pages, 1 appendix

Type 2 diabetes is an increasingly common disease worldwide, and studies have shown that among individuals with diabetes 44-68% are previously undiagnosed. They do not have a previous diagnosis of type 2 diabetes, but their fasting plasma glucose level is ≥ 7.0 mmol/l or 2 h plasma glucose in oral glucose tolerance test is ≥ 11.1 mmol/l. Regular leisure time physical activity is known to reduce the risk of developing type 2 diabetes, but the potential impact of lifestyle activity and work related physical activity is still partly uncertain. The aim of this study was to investigate whether physical activity of previously undiagnosed (screen-detected) type 2 diabetics differ from physical activity of previously diagnosed (known) type 2 diabetics, and determine in which types of physical activity screen-detected type 2 diabetics differ from non-diabetics.

This study is part of the cross-sectional population-based FIN-D2D survey, that studies the prevalence of obesity, type 2 diabetes, and other disturbances in glucose metabolism in Finland. A random sample of 4500 subjects aged 45-74 years was invited to a health examination that included an oral glucose tolerance test. Participation rate was 62% among men and 67% among women. The physical activity was assessed by a self-administered questionnaire. Results were analyzed by using logistic and linear regression analysis.

In women screen-detected type 2 diabetics were physically more passive than known type 2 diabetics. Age-adjusted statistically significant differences were found in the duration of physical activity sessions ($P = 0.041$) and the number of physical activity sessions at a moderate intensity per week ($P = 0.002$). The same differences were statistically significant also between screen-detected type 2 diabetics and non-diabetics women ($P = 0.014$ and 0.001) the non-diabetics being more active. Moreover, overall leisure time physical activity was significantly lower among screen-detected type 2 diabetics compared to non-diabetics ($P = 0.001$) when analyzed based on a dichotomized classification.

In men there were no statistically significant differences in physical activity between screen-detected type 2 diabetics and known type 2 diabetics. Participation in leisure time physical activities ($P = 0.001$) and lifestyle physical activities ($P = 0.014$) were significantly lower among screen-detected type 2 diabetics compared to non-diabetics. A significant difference was also found in the number of physical activity session per week ($P = 0.017$).

In conclusion, our results show that screen-detected type 2 diabetics women were physically more passive than known type 2 diabetics, but in men that difference was not seen. Non-diabetics were physically more active compared to screen-detected type 2 diabetics in both genders. This study supports the current view that regular physical activity protects against the development of type 2 diabetes, and gives also indirect evidence that in women diagnosis of type 2 diabetes and the following exercise counseling produce the desired increase of physical activity.

Key Words: physical activity, screen-detected type 2 diabetes, known type 2 diabetes

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1 INTRODUCTION

Type 2 diabetes is not only an increasingly common disease worldwide, but also an important risk factor for cardiovascular diseases and premature mortality (Decode Study Group 2001, Vaccaro et al. 2004). Long symptomless period with impaired fasting glucose (IFG) or impaired glucose tolerance (IGT) usually precede type 2 diabetes. IFG and IGT are intermediate stages in the progression of type 2 diabetes (Edelstein et al. 1997). In addition to known type 2 diabetics, there are a lot of people who fulfill the clinical diagnostic criteria of type 2 diabetes, but who still have not symptoms of disease. Some previous studies have shown that there are almost as much undiagnosed (screen-detected) type 2 diabetics as known type 2 diabetics in the population (Glumer et al. 2003, Ylihärsilä et al. 2005, Wong & Wang 2006).

Randomized controlled trials have demonstrated that lifestyle changes, such as regular physical activity and healthy diet, can prevent type 2 diabetes (Pan et al. 1997, Knowler et al. 2002, Tuomilehto et al. 2001, Ramachandran et al. 2006). The results from previous Finnish study suggested that the reduction in the incidence of type 2 diabetes is directly associated with number and magnitude of lifestyle changes made. In that study the risk of diabetes was reduced by 58% in the intervention group compared to the control group (Tuomilehto et al. 2001). In the Chinese Da Qing Impaired Glucose Tolerance and Diabetes Study diabetes risk was reduced 46% in the exercise group, 42% in the diet and exercise group, and 31% in the diet-treated group (Pan et al. 1997). Moreover, Laaksonen et al. (2005) found that regular physical activity reduced the risk of developing type 2 diabetes in high-risk individuals independent of dietary changes and weight reduction.

Various epidemiological studies have shown that leisure time physical activity at a moderate or vigorous intensity protects against the development of type 2 diabetes (Manson et al. 1991, Manson et al. 1992, Lynch et al. 1996, Hu et al. 1999, Hu et al. 2003, Kriska et al. 2003, Meisinger et al. 2005). Aerobic leisure time physical activity and exercise training has traditionally been emphasized as being effective in reducing diabetes risk, but only few studies have assessed leisure time physical activity, low intensity lifestyle activities and work related physical activity separately (Mayer-Davis et al. 1998, Hu et al. 2003). Hu et al. (2003) found that the hazard ratios of type 2 diabetes for moderate and active work compared to light work were 0.70 and 0.74, and hazard ratios of diabetes for moderate and high levels of leisure

time physical activity compared to low levels were 0.67, and 0.61. In addition, Mayer-Davis et al.'s findings (1998) showed that increased participation in nonvigorous lifestyle activities and vigorous physical activities was positively and independently associated with significantly higher insulin sensitivity.

Large-scale prospective studies indicate that higher levels of physical activity are clearly associated with a lower incidence of type 2 diabetes in a dose-response manner (Kelley & Doodpaster 2001), but no randomized controlled trials have been conducted to directly address the dose-response effect of exercise on diabetes prevention. However, there is limited indirect evidence for this. In Laaksonen et al.'s study (2005) participants in the upper third of the change in total leisure time physical activity (mean 3.8 hours per week) were 66% less likely to develop diabetes than those in the lower third (-3.2 hours per week) (relative risk [RR] 0.34, 95% confidence interval [CI] 0.19–0.62) after multivariate adjustment. Participants in the middle third of the change in total leisure time physical activity (mean 0.5 hours per week) were 48% less likely to develop diabetes than those in the lower third (RR 0.52, 95% CI 0.31–0.89; $P < 0.001$ for linear trend). Furthermore, the relative risks of developing type 2 diabetes for the upper third (mean 2.6 hours per week) and the middle third (mean 0.5 hours per week) of the change in moderate to vigorous leisure time physical activity (≥ 3.5 METs) compared to the lower third (mean –1.5 hours per week) were 0.51 and 0.95. The relative risks of developing type 2 diabetes for the upper third (mean 3.1 hours per week) and the middle third (mean 0.1 hours per week) of the change in low intensity leisure time physical activity (< 3.5 METs) compared to the lower third (mean –3.2 hours per week) were 0.36 and 0.63 after multivariate adjustment.

Despite of previous promising study results, the potential impact of leisure time physical activity and especially lifestyle activities and work related physical activity is still partly uncertain. Therefore, more evidence on the role of different types of physical activity in the prevention of type 2 diabetes is needed. In this study we have assessed leisure time physical activity, lifestyle activities and work related physical activity separately. Moreover, we have examined screen-detected type 2 diabetics, known type 2 diabetics and non-diabetics as their own groups, which has not, to our knowledge, been clarified in previous studies. We hypothesized that lower levels of different types of physical activity would be more common among screen-detected type 2 diabetics, because physical activity has prevented type 2

diabetes among non-diabetics, and known type 2 diabetics have probably increased physical activity due to exercise counseling.

Exercise counseling is effective for promoting physical activity and can motivate most patients with type 2 diabetes to exercise (Di Loreto et al. 2003, Kirk et al. 2004). Kirk et al. (2004) found that over one year type 2 diabetics who received exercise counseling increased total physical activity on average of 115 minutes (95% CI = 73-150 minutes) measured by physical activity recall, whereas diabetics who did not receive exercise counseling recorded no significant change (median difference -15 minutes; 95% CI = -53-13 minutes). Di Loreto et al.'s findings (2003) showed that after 2 years, type 2 diabetics who received structured exercise counseling increased energy expenditure through voluntary physical activity from 0.8 ± 0.2 to 27.1 ± 2.0 METs · h/week ($P < 0.001$), a value that was sevenfold greater ($P < 0.001$) than in diabetics who were treated with usual care (4.1 ± 0.8 METs · h/week).

The aim of this study was to investigate whether physical activity of screen-detected type 2 diabetics differ from physical activity of known type 2 diabetics. The aim was also to determine in which types of physical activity screen-detected type 2 diabetics differ from non-diabetics.

2 METHODS

2.1 Subjects

This study is part of the FIN-D2D survey, that studies prevalence of obesity, type 2 diabetes, and other disturbances in glucose metabolism in a Finnish adult population. The FIN-D2D survey was carried out in hospital districts of South Ostrobothnia, Central Finland and Pirkanmaa during October 2004 and January 2005. A random sample of 4500 subjects 45-74 years of age was selected from the National Population Register according to 10-year age groups, gender and area in September 2004.

2.2 Data collection

The subjects were invited by mail for a clinical examination and at the same time they also received a self-administered questionnaire to be filled in at home before arriving at the health examination. The questionnaire included questions of socioeconomic background, medical history, and health behavior. The Research Ethics Committee of The Hospital District of Helsinki and Uusimaa approved the study protocol, and subjects provided their written informed consent prior participation to the study.

Health examination followed the MONICA protocol (World Health Organization 1990). Height, weight and waist circumference were measured by trained nurses and body mass index (BMI) was calculated as weight (kg) divided by height^2 (m^2). An oral glucose tolerance test (OGTT) was performed according to the World Health Organisation (WHO) quidelines (World Health Organization 1999). A 300 ml test solution contained 75 g anhydrous glucose and 1.6 g citric acid. The test started after at least 8 hours fast, and the 2-hour blood sample was obtained 120 minutes after the ingestion of the solution. Fasting and 2-hour samples for the plasma glucose determination were drawn into fluoridated tubes and centrifuged within 30 minutes. Plasma glucose was determined with a hexokinase method (Thermo Electron Corporation, Vantaa, Finland) and the serum insulin concentration was measured by a microparticle enzyme immunoassay (Axsym, Abbott Diagnostics Division, Wiesbaden, Germany). All assays were performed at Laboratory of Analytical Biochemistry in National Public Health Institute, Helsinki, Finland.

The glucose tolerance was classified according to the WHO 1999 criteria (World Health Organization 1999). Subjects who reported that they have type 2 diabetes were not included in the oral glucose tolerance test, and were classified as known type 2 diabetics. Subjects who were not known type 2 diabetics, and had fasting plasma glucose level ≥ 7.0 mmol/l or 2 h plasma glucose ≥ 11.1 were classified as screen-detected type 2 diabetics. In this study subjects who have neither known type 2 diabetes nor screen-detected type 2 diabetes were classified as non-diabetics. Therefore, subjects with either impaired fasting glucose or impaired glucose tolerance were also included in the group of non-diabetics.

The physical activity was assessed by a self-administered questionnaire, which contained questions about the physical strenuousness of work and the duration and frequency of at least moderate intensity leisure time physical activity and low intensity lifestyle activities (appendix 1). In this study leisure time physical activity included e.g. walking, cycling, swimming, jogging, skiing, ball games and fitness training. Lifestyle activities were defined as activities that are commonly performed in gardening and general housework, and commuting physical activity were defined as walking or cycling to and from work.

For statistical analyses different types of physical activity were dichotomised as follows: In the questionnaire, physical strenuousness of work was identified using a structured question with 4 alternatives (question 73 in appendix). There was a dichotomy between the sedentary work (alternative 1) and the work that contains lot of walking, raising or carrying (alternatives 2-4). The question of overall leisure time physical activity (question 74) included 4 alternatives. Those who reported participating in activities, which do not physically strain (alternative 1) were classified as physically inactive, and those who reported participating in activities at a low or moderate intensity, or competitive sports were classified as physically active (alternatives 2-4). Frequency of leisure time physical activity at a moderate intensity at least 20-30 minutes was classified using question with 6 alternatives (question 76). Subjects who reported that they exercise daily or 2-3 times per week were classified as active (alternatives 1-2), and subjects who reported that they exercise once a week or less frequently were classified as inactive (alternatives 3-6). The question of average duration of physical activity session (question 78) included 5 alternatives. Those who reported average duration < 30 minutes were classified as inactive (alternatives 0-2), and those who reported average duration at least 30 minutes were classified as active (alternatives 3-4). Commuting physical activity (question 75 with 6 alternatives) and lifestyle physical activity (question 79 with 5

alternatives) was categorized into two groups: those who reported participating < 30 minutes per day were classified as inactive, and those who reported participating at least 30 minutes per day were classified as active. The dichotomies are shown also in Table 3 and 4.

2.3 Statistical analyses

Statistical analyses were performed with SPSS version 14.0 for Windows. Subjects who did not participate in health examination (n = 1604) or who had problems in the oral glucose tolerance test (n = 71) were excluded from the analyses. Totally, 1364 men and 1461 women were included in the analyses, but there were missing data for 3-212 persons in the questions of physical activity. Detailed information of the participation rates in this study are shown in Table 1. Crosstabulations were used to analyze the differences of physical activity between known type 2 diabetics, screen-detected type 2 diabetics and non-diabetics. Statistical differences (*P* values) were determined using logistic regression analysis (Wald's test), except for differences in the number of physical activity sessions per week, which was determined with the linear regression analysis. Analyses were done separately for both genders, and adjusted for age, education years and questionnaire-reported diseases such as myocardial infarction, stroke, cerebral hemorrhage, rheumatoid arthritis, backache or articular pain of knee or hip, which may cause limitations for the physical activity. Statistical significance was defined as $P < 0.05$ (two-sided) for all tests.

Table 1. The participation rates.

	MEN		WOMEN	
	n	%	n	%
Sample	2250		2250	
Participate in health examination	1396	62.0	1500	66.7
Problems in the OGTT[1]	32	2.3	39	2.6
Included in the analyses	1364	60.6	1461	64.9

[1] Refusal of OGTT (n = 3), fasting time was unknown or under 8 hours (n = 12), incomplete drinking of glucose solution (n = 3), vomiting during OGTT (n = 3), the time between drinking of glucose solution and 2-hour blood sample deviated more than 15 minutes from 2 hours limit (n = 15), technical problems with OGTT (n = 35).

3 RESULTS

Characteristics of the study population by gender are described in Table 2. Distribution of known type 2 diabetics, screen-detected type 2 diabetics and non-diabetics differed between genders as more men (8.3%) than women (4.8%) belonged to the known type 2 diabetics. Also screen-detected type 2 diabetes was more common in men than in women (9.2% vs. 7.5%). Non-diabetics were of average age younger than known type 2 diabetics and screen-detected type 2 diabetics, and they were also thinner than the members of other two groups in both gender. Diseases which cause limitations for physical activity were more common in women than in men in all study groups.

Table 2. Characteristics of the subjects by gender, totally 1364 men and 1461 women.

	MEN			WOMEN		
	n (%)	Mean ± SD	Range	n (%)	Mean ± SD	Range
Known type 2 diabetics	113 (8.3)			70 (4.8)		
Age (y)		63.9±6.7	46.0-74.6		64.1±7.8	45.4-74.8
Height (cm)		175.9±6.7	159.4-190.7		160.9±5.6	148.8-180.0
Weight (kg)		96.5±17.9	66.6-155.0		80.7±15.9	50.0-121.9
BMI (kg/m^2)		31.1±5.2	21.2-44.9		31.1±5.8	20.9-47.4
Waist (cm)		109.6±12.9	87.0-147.0		99.8±15.6	63.6-140.0
Education (y)		9.9±3.4	6-21		9.0±3.0	0-18
Diseases[1]	74 (65.5)			54 (77.1)		
Screen-detected type 2 diabetics	125 (9.2)			110 (7.5)		
Age (y)		63.2±8.1	45.7-75.0		64.2±7.6	45.6-75.0
Height (cm)		174.9±6.8	160.3-196.0		160.5±5.2	149.6-175.2
Weight (kg)		89.7±17.7	50.8-140.0		80.5±16.8	54.1-123.3
BMI (kg/m^2)		29.2±5.1	18.4-47.0		31.2±6.1	20.4-46.1
Waist (cm)		104.6±13.1	72.5-139.5		98.9±14.2	71.0-136.5
Education (y)		10.1±7.0	1-75		9.8±3.1	5-20
Diseases[1]	77 (61.6)			80 (72.7)		
Non-diabetics	1126 (82.5)			1281 (87.7)		
Age (y)		59.6±8.3	45.2-75.1		59.2±8.4	45.2-75.2
Height (cm)		175.6±6.3	158.2-195.3		162.3±5.8	131.6-180.5
Weight (kg)		83.8±13.1	48.4-160.0		71.8±13.2	42.0-153.8
BMI (kg/m^2)		27.1±3.7	17.3-47.3		27.3±4.9	17.3-57.2
Waist (cm)		97.7±10.8	56.5-161.0		88.5±12.7	60.0-150.0
Education (y)		10.6±4.3	0-70		11.0±3.7	2-53
Diseases[1]	698 (62.0)			855 (66.7)		

[1] At least one of next diseases which cause limitations for physical activity: myocardial infarction, stroke, cerebral hemorrhage, rheumatoid arthritis, backache or articular pain of knee or hip.

In women physical activity was on average more common among known type 2 diabetics than screen-detected type 2 diabetics (Table 3). 58.0% of screen-detected type 2 diabetics and 73.8% of known type 2 diabetics reported the average duration of physical activity sessions at least 30 minutes, the difference being statistically significant after adjustment for age (P = 0.041). After further adjustment for education and diseases, the difference remained statistically significant (P = 0.044).

Screen-detected type 2 diabetics women performed average of 1.98 physical activity sessions sweating and becoming breathless per week, when the same number for known type 2 diabetics was 3.04. Age-adjusted difference was statistically significant (P = 0.002) (Table 5). Similar statistically non-significant trends were found for work related physical activity, leisure time physical activity and commuting physical activity, as shown in Table 3 (age-adjusted P = 0.423-0.545).

A statistically significant difference was found between screen-detected type 2 diabetics and non-diabetics women in leisure time physical activity (age-adjusted P = 0.001) and duration of physical activity (age-adjusted P = 0.014) (Table 3). After further adjustment for education years and diseases, the differences remained at least borderline significant (P = 0.004 and 0.051). The reported number of physical activity session per week was lower among screen-detected type 2 diabetics than non-diabetics women (1.98 vs. 2.73), and the difference was statistically significant after multivariate adjustment (P = 0.002) (Table 5).

Table 3. Physical activity of women.

	Known type 2 diabetics				Screen-detected type 2 diabetics				Non-diabetics		
	n	%*	95% CI		n	%*	95% CI		n	%*	95% CI
Work related PA[1]	14	32.6	19.1-48.5		22	23.9	15.6-33.9		476	43.5	40.5-46.4
P[a]				0.292				< 0.001			
P[b]				0.483				0.145			
P[c]				0.464				0.176			
Leisure time PA[2]	45	72.6	59.8-83.1		70	66.7	57.6-75.7		1006	80.7	78.5-82.9
P[a]				0.426				0.001			
P[b]				0.423				0.001			
P[c]				0.345				0.004			
LTPA at a moderate intensity[3]	40	62.5	49.5-74.3		62	57.9	48.6-67.3		810	65.4	62.7-68.0
P[a]				0.557				0.124			
P[b]				0.545				0.067			
P[c]				0.752				0.088			
Duration of PA[4]	45	73.8	60.9-84.2		58	58.0	47.7-67.3		863	71.7	68.5-73.6
P[a]				0.045				0.007			
P[b]				0.041				0.014			
P[c]				0.044				0.051			
Commuting PA[5]	8	14.0	6.3-25.8		9	10.0	4.7-18.1		169	15.1	13.0-17.2
P[a]				0.458				0.192			
P[b]				0.458				0.597			
P[c]				0.901				0.691			
Lifestyle PA[6]	39	60.9	47.9-72.9		61	61.6	51.3-71.2		763	63.6	60.9-66.3
P[a]				0.931				0.688			
P[b]				0.902				0.188			
P[c]				0.975				0.156			

[1] Work contains at least lot of walking or also lifting and carrying.
[2] Low-intensity lifestyle activities ≥ 4 hours per week or leisure time physical activity at a moderate or vigorous intensity ≥ 3 hour per week.
[3] 20-30 minute leisure time physical activity sweating and becoming breathless ≥ 2-3 times per week.
[4] Average duration of physical activity session ≥ 30 minutes.
[5] Walking or cycling to and from work ≥ 30 minutes per day.
[6] Activities that are commonly performed in gardening and general housework ≥ 30 minutes per day.
[a] Non-adjusted statistical difference between two groups
[b] Age-adjusted
[c] Adjusted for age, education years and diseases which cause limitations for physical activity
* For those who respond to the specific question

No differences in physical activity were seen between screen-detected and known type 2 diabetics men (Table 4). When comparing screen-detected type 2 diabetics with non-diabetics men, the reported participation in leisure time physical activities (72.1% vs. 82.8%) and lifestyle physical activities (45.7% vs. 50.4%) were more common among non-diabetics (Table 4). The age-adjusted differences between groups were statistically significant (P = 0.001 and P = 0.014). Screen-detected type 2 diabetics reported a mean of 2.22 of physical activity session per week, which was significantly less than non-diabetics, who reported 2.59 session per week (age-adjusted P = 0.017) (Table 5). All these differences remained significant after further adjustment for education years and diseases (P = 0.001-0.030). Similar trends were also found in work related physical activity, leisure time physical activity at a moderate intensity, and the duration of physical activity, but they were not statistically significant (age-adjusted P = 0.068-0.997).

Table 4. Physical activity of men.

	Known type 2 diabetics				Screen-detected type 2 diabetics				Non-diabetics		
	n	%*	95% CI		n	%*	95% CI		n	%*	95% CI
Work related PA[1]	32	38.1	27.7-49.3		43	39.8	30.6-49.0		485	48.6	45.5-51.7
P[a]				0.809				0.082			
P[b]				0.996				0.997			
P[c]				0.937				0.993			
LTPA[2]	72	67.3	58.4-76.2		88	72.1	64.2-80.1		907	82.8	80.5-85.0
P[a]				0.426				0.004			
P[b]				0.408				0.001			
P[c]				0.599				0.001			
LTPA at a moderate intensity[3]	54	50.9	41.4-60.5		67	54.9	46.1-63.7		645	59.2	56.3-62.1
P[a]				0.549				0.537			
P[b]				0.461				0.670			
P[c]				0.411				0.619			
Duration of PA[4]	60	60.6	50.3-70.3		71	60.2	46.1-63.7		708	67.9	65.1-70.8
P[a]				0.948				0.359			
P[b]				0.980				0.068			
P[c]				0.792				0.114			
Commuting PA[5]	9	9.3	4.3-16.9		12	10.9	5.0-16.6		93	9.1	7.4-11.0
P[a]				0.698				0.089			
P[b]				0.666				0.081			
P[c]				0.841				0.200			
Lifestyle PA[6]	48	47.1	37.4-56.7		53	45.7	36.6-54.8		524	50.4	47.4-53.5
P[a]				0.840				0.333			
P[b]				0.912				0.014			
P[c]				0.915				0.026			

[1] Work contains at least lot of walking or also lifting and carrying.
[2] Low-intensity lifestyle activities ≥ 4 hours per week or leisure time physical activity at a moderate or vigorous intensity ≥ 3 hour per week.
[3] 20-30 minute leisure time physical activity sweating and becoming breathless ≥ 2-3 times per week.
[4] Average duration of physical activity session ≥ 30 minutes.
[5] Walking or cycling to and from work ≥ 30 minutes per day.
[6] Activities that are commonly performed in gardening and general housework ≥ 30 minutes per day.
[a] Non-adjusted statistical difference between two groups
[b] Age-adjusted
[c] Adjusted for age, education years and diseases which cause limitations for physical activity
* For those who respond to the specific question

Table 5. Number of physical activity sessions by sweating and becoming breathless per week.

	Known type 2 diabetics			Screen-detected type 2 diabetics			Non-diabetics	
	Mean±SD	Range		Mean±SD	Range		Mean±SD	Range
Men	2.09±2.2	0-14		2.22±2.1	0-7		2.59±2.5	0-44
P[a]			0.681			0.131		
P[b]			0.631			0.017		
P[c]			0.476			0.030		
Women	3.04±2.4	0-10		1.98±1.8	0-7		2.73±2.3	0-23
P[a]			0.002			0.002		
P[b]			0.002			0.001		
P[c]			0.008			0.002		

[a] Non-adjusted statistical difference between two groups
[b] Age-adjusted
[c] Adjusted for age, education and diseases which cause limitations for physical activity

4 DISCUSSION

To our knowledge, this was the first study investigating physical activity among screen-detected type 2 diabetics. Our results provide new information on the differences of physical activity between known type 2 diabetics and screen-detected type 2 diabetics. In women known type 2 diabetics were physically more active than screen-detected type 2 diabetics. Age-adjusted statistically significant differences were specifically found in the average duration of physical activity sessions and the number of physical activity sessions at a moderate intensity per week. More detailed information of the average duration of physical activity sessions are shown in Figure 1. These differences remained statistically significant after further adjustment for education years and diseases which cause limitations for physical activity. In men we did not find any age-adjusted statistically significant differences between screen-detected type 2 diabetics and known type 2 diabetics.

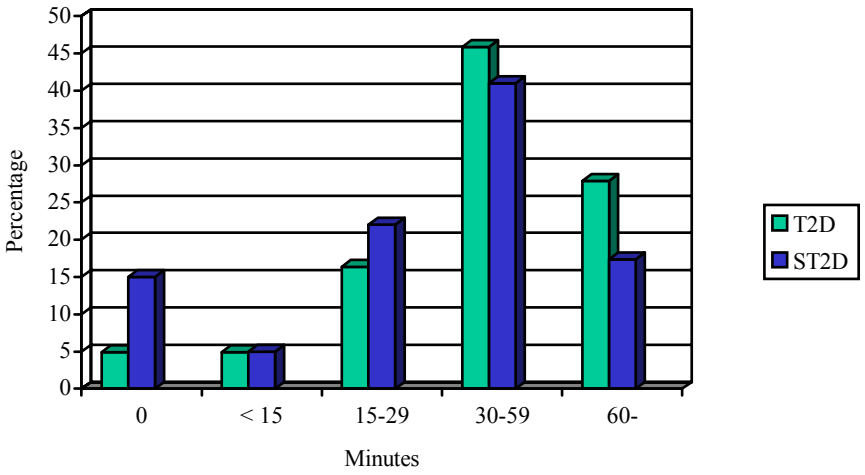

Figure 1. The average duration of physical activity sessions without dichotomy among known type 2 diabetics (T2D) and screen-detected type 2 diabetics (ST2D) women. Percentages are presented for those who responded to the question.

Wee et al. (1999) and Morrato et al. (2006) suggested that health care professionals recognize the importance of exercise for individuals with diabetes. Diabetics were more likely to be advised by a health care professional to exercise more compared to those without diabetes. Similarly, when risk factors for type 2 diabetes such as cardiac diseases and overweight increased, advice to exercise was more likely. Moreover, Di Loreto et al. (2003) and Kirk et al. (2004) found that type 2 diabetics who received exercise counseling increased physical

activity and energy expenditure compared to diabetics who did not receive exercise counseling. Our findings may indicate that type 2 diabetics women are more responsive to the exercise counseling compared to men. The duration and number of physical activity sessions are important components in the exercise counseling of type 2 diabetics, and as our results showed, there were statistically significant differences exactly in those areas of the physical activity among women, but not in men. Thus, in the future it may be justified to pay more attention to more intensive exercise counseling to especially type 2 diabetics men.

As expected based on previous studies our results showed that physical activity was lower among screen-detected type 2 diabetics compared to non-diabetics. A statistically significant difference was found between screen-detected type 2 diabetics and non-diabetics women in leisure time physical activity, duration of physical activity and number of physical activity session per week. In men we found statistically significant differences in reported participation in leisure time physical activities and lifestyle physical activities, and also in the number of physical activity session per week. All these differences in both genders remained statistically significant after further multivariate adjustment.

Also other studies have shown that greater leisure time physical activity level is associated with reduction in the incidence of type 2 diabetes in both genders (Manson et al. 1991, Manson et al. 1992, Lynch et al. 1996, Hu et al. 1999, Hu et al. 2003, Kriska et al. 2003, Meisinger et al. 2005). Manson et al. (1991) found that women who engaged in vigorous leisure time physical activity at least once per week had an age-adjusted relative risk of non-insulin-dependent diabetes mellitus of 0.67 ($P > 0.0001$) compared with those who exercised less frequently. In an other study Manson et al. (1992) reported that in men the relative risk was 0.64 ($P = 0.0003$). Also Hu et al.'s findings (2003) showed that in both genders combined, the multivariate-adjusted hazard ratios of diabetes for moderate and high levels of leisure-time physical activity compared to low levels were 0.67, and 0.61 ($P = 0.001$ for trend). Contrary to those results, Meisinger et al. (2005) suggested that after adjustment for confounding factors highly active women (more than 2 hours physical activity per week) had the lowest risk of type 2 diabetes. In highly active women the hazard ratio of diabetes was 0.24, whereas in highly active men the hazard ratio was 0.83.

Not only leisure time physical activity but also work related and commuting physical activities are important components in reducing the risk of type 2 diabetes. Hu et al. (2003)

have reported that work related or commuting physical activity at a moderate or high intensity can independently and significantly reduce the risk of type 2 diabetes. In their study the multivariate adjusted hazard ratios of diabetes for moderate and active work compared to light work were 0.70 and 0.74 (P = 0.020 for trend), and the hazard ratios of diabetes with 1 to 29, and more than 30 min of walking or cycling to and from work compared to none commuting physical activity were 0.96, and 0.64 (P = 0.048 for trend) in men and women combined. Unexpectedly, we did not find any statistically significant differences in work related physical activity or commuting physical activity in women or in men. This may be because of low participation rates in physically strenuous work and commuting physical activity at least 30 minutes per day (Table 3 and 4).

The present study has certain limitations. First, more than 1600 individuals did not participate in health examination of FIN-D2D survey. Those who did not participate were more often young men aged 45-54 years. Moreover, there were also incomplete responds in the physical activity questionnaire. Therefore, we have presented our percentual results for those who had responded to the specific question. Another limitation of this study was the use of self-reported data of physical activity. Thus, some recall bias cannot be avoided, and it is possible that individuals probably exaggerate the amount of physical activity in the questionnaires. In this study results were adjusted by age, education years and the most common diseases of cardiovascular and musculoskeletal systems, but other chronic diseases, that also can cause limitations for physical activity, were not taken into account (e.g. multiple sclerosis or Parkinson's disease).

In conclusion, our results showed that non-diabetics were physically more active compared to type 2 diabetics and screen-detected type 2 diabetics. Thus, our study supports the current view that regular physical activity protects against the development of type 2 diabetes. This study also provides new information about the physical activity among screen-detected type 2 diabetics. Our results showed that women with screen-detected type 2 diabetes were physically more passive than known type 2 diabetics, but in men that difference was not seen. This may indicate that in women diagnosis of type 2 diabetes and the following exercise counseling produce the desired increase of physical activity, but there is a need for development of more effective exercise counseling practice to especially for type 2 diabetics men. Also more studies are needed to investigate the associations between different types of physical activity and screen-detected type 2 diabetes.

Acknowledgement

My special thanks are offered to the research group of FIN-D2D survey, who gave me the data and made possible to write this Master's Thesis. I want to give my thanks to Professor Urho Kujala for great advice and valuable counsel during all stages of this study. I thank Associate Professor Markku Peltonen from Diabetes Unit of National Public Health Institute for thought-inspiring comments and for statistical advice.

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PHYSICAL ACTIVITY QUESTIONNAIRE

73. How strenuous is your work physically?
The activity at work is divided into four groups. If you do not work mark 1.

1 ☐ My work is mainly sedentary work and I do not walk much during my working hours (e.g. a clockmaker, radio mechanic and industrial seamstress, office work at a desk).

2 ☐ I walk quite much in my work, but I do not have to lift or carry heavy objects (e.g. a foreman and store assistant, light industrial worker, office work which requires walking).

3 ☐ I have to walk and lift much or take the stairs or go uphill in my work (e.g. a carpenter or cattle tender, engineering shop or other heavier industrial work).

4 ☐ My work is heavy manual labor in which I have to lift or carry heavy objects, to dig, shovel or chop (e.g. forestry, heavy farm work, heavy construction or industrial work).

74. How much do you exercise and stress yourself physically in your leisure time?
If it varies much according to different seasons, mark the alternative which best describes the average situation.

1 ☐ In my leisure time I read, watch TV, and work in the household with tasks which do not make me move much and which do not physically tax me.

2 ☐ In my leisure time I walk, cycle or exercise otherwise at least 4 hours per week. This includes walking, fishing and hunting, light gardening etc. but excludes travel to work.

3 ☐ In my leisure time I exercise to maintain my physical condition, e.g. running, jogging, skiing, gymnastics, swimming, playing ball games or I do heavy gardening or the like for at least 3 hours per week.

4 ☐ In my leisure time I regularly exercise several times a week competitive sports such as running, orienteering, skiing, swimming, playing ball games or other heavy sports.

75. How many minutes do you walk, cycle or otherwise exercise to get to work?
(Please count in both traveling to and from work.)

1 ☐ I do not work or I use only a motorized vehicle

2 ☐ less than 15 minutes daily

3 ☐ 15 - 29 minutes daily

4 ☐ 30 - 44 minutes daily

5 ☐ 45 - 59 minutes daily

6 ☐ over an hour daily

76. How often do you exercise in your leisure time for at least 20-30 minutes so that you at least are mildly out of breath and sweaty?

1 ☐ daily

2 ☐ 2-3 times a week

3 ☐ once a week

4 ☐ 2-3 times a month

5 ☐ a few times a year or more seldom

6 ☐ I have a disability or a disease which does not enable me to exercise (proceed to question 79)

77. How many times per week do you exercise in your leisure time so that you at least are mildly out of breath and sweaty?
(if not at all, mark 0.)

|__|__| times per week

78. How much time does your usual leisure time physical activity takes?

0 ☐ I do not exercise in my leisure time

1 ☐ less than 15 minutes

2 ☐ 15 - 29 minutes

3 ☐ 30 - 59 minutes

4 ☐ one hour or longer

79. How many minutes do you daily walk, cycle or engage in a hobby in your leisure time that requires moving around (yard work or gardening, fixing or cleaning the house)?
Do not count in the activity needed at work, traveling to work (question 75) or leisure time sports (questions 76-78).

1 □ less than 15 minutes per day

2 □ 15-29 minutes per day

3 □ 30-44 minutes daily

4 □ 45-59 minutes daily

5 □ over an hour per day