Sport disciplines, types of sports and waist circumference in young adulthood - a population based twin study

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Keywords: Physical activity, exercise mode, abdominal obesity, epidemiological study

What are the findings?

- Among young adults in their mid-30s, the number of participated sport disciplines was inversely associated with waist circumference, also in pairwise analysis among sports participation discordant dizygotic twin pairs.
- Shared genetic background may explain some of the associations, as sports participation discordant monozygotic twin pairs did not have difference in waist circumference.
- In men, all three types of sports (aerobic, power and mixed) were individually associated with smaller waist circumference, while in women, only mixed and power sports associated with favourable levels of waist circumference.

How might it impact on clinical practice in the future?

- Promoting diverse sports participation than focusing on specific sports may be beneficial in terms of abdominal obesity prevention among young adults.
- Sport disciplines that are popular in real-life could in various ways be incorporated to the future intervention studies testing feasible ways to prevent waist circumference increase.

ABSTRACT

Background/Aim: The benefits of physical activity in the prevention of abdominal obesity are well recognized, but the role of different sport disciplines remains open. Therefore, we aimed to investigate how participation in different sport disciplines and sport types are associated with waist circumference (WC) in young adulthood.

Methods: Population-based cohort study comprised of 4027 Finnish twin individuals (1874 men), who responded to a survey at mean age of 34 y (32-37), and self-measured WC. The participation in different sport disciplines was reported, and further, the number of different sport disciplines and the types of sports (aerobic, power, mixed) participated in were identified.

Results: The number of participated sport disciplines was inversely associated to waist circumference, linear decrease being on average 1.38 cm (s.e. 0.14, $P<0.001$) per each additional sport discipline. Result persisted after adjustment for main covariates, such as volume of activity (1.04cm, s.e. 0.14, $P<0.001$) and diet quality (0.95cm, s.e. 0.14, $P<0.001$). Among sports participation discordant dizygotic twin pairs (0-2 vs. 5 or more disciplines), the mean within-pair difference in WC was 4.8 cm ($P=0.033$) for men and 11.2cm ($P= 0.003$) for women, but no differences were seen among discordant monozygotic pairs. In men, all three types of sports were individually associated with smaller WC, while in women, only mixed and power sports associated with smaller WC.

Conclusion: Participation in several sport disciplines and sport types was associated with smaller WC among young adults in their mid-30s. Shared genetic background may explain some of the associations.

INTRODUCTION

The location of body fat seems to have more important influence on cardio-metabolic health than general obesity. [1] Abdominal obesity is independently related to type 2 diabetes, cardiovascular diseases, and their risk factors [2-4] as well mortality. [5] Waist circumference (WC) measurement is considered to be a valid marker of abdominal obesity, [6,7] and it is easy and affordable to carry out in clinical practice and large population studies. Abdominal obesity has become increasingly common among younger people, [8,9] and therefore strategies to prevent it at early stages are important to minimize the development of related health problems.

Physical activity (PA) has good potential to prevent and reduce abdominal obesity. Longitudinal studies have shown that regular PA is related to favourable levels of WC, [10-12] and randomized controlled trials have confirmed the beneficial independent role of moderate to vigorous aerobic exercise in reducing abdominal fat among people with overweight and obesity. [13,14] However, several questions considering optimal exercise modality to prevent and treat abdominal fat accumulation remain open. Exercise trials have mainly focused on the effects of aerobic exercise and strength training, [13] and observational studies have usually taken into account general levels of PA instead of specific exercise modes. [10,11] Recently, the health benefits of different sport disciplines have been under discussion,[15,16] but the evidence regarding the effect of specific sports participation on body composition is sparse.

The purpose of our study was to investigate how participation in different sport disciplines, the number of participated sport disciplines and types of sports are associated with WC in young adulthood. This knowledge from real-life setting could be beneficial when planning future intervention trials and in clinical health promotion to find optimal way to prevent and reduce abdominal obesity. Both exercise participation [17] and abdominal obesity[18,19] have genetic components. There may be shared genetic effects influencing both sports participation and abdominal obesity. Our co-twin control study design permits taking into account childhood family environment as well as genetic effects either fully (monozygotic, MZ twin pairs) or partially (dizygotic, DZ twin pairs).

MATERIALS AND METHODS

Data collection

This study is part of the population based FinnTwin16 cohort study [20] investigating the role of genetic and environmental factors as determinants of different health behaviours, disease risk factors and chronic disease. Virtually all twins born between October 1974 and December 1979 were identified from the Finnish population register , and data collection started when the twins aged 16. In the current study we used the fifth wave of data collection, which was conducted in 2010–2012. . Data collection was conducted using a web-based questionnaire including questions related to health, body composition and LTPA. Twins were mailed an invitation letter that contained the access code to the Internet survey. [12]

This study was conducted according to ethical standards and the Declaration of Helsinki, and approved by the ethics committee of the Central Finland Hospital district. Participants gave their informed consent.

Participants

Altogether 4406 twin individuals (men 1962, 44.5%) responded to the questionnaire at 32-37 (mean 34.0) years of age, with response rate of 71.9% based on all cohort members alive and resident in Finland. [21] All the participants who responded the questions related to LTPA, weight and height, and measured their WC were included in this study. Pregnant women at the time of data collection (n=197) were excluded. The final study group comprised of 4027 twin individuals (1874 men and 2153 women) including 1443 twin pairs with both twins participating (492 MZ and 894 DZ).

Measurement of waist circumference

WC was self-measured with a supplied tape measure that was included in the mailed invitation letter. [12] Web-based questionnaire included the instructions with an illustration for measuring WC. Measurement was performed while standing, at either the narrowest part of the waist, or if that was not found, the midpoint between the lowest part of the ribs and top of the hip bone. Self-measured and healthcare professional-measured WC (n=24) have a high intra-class correlation (r=0.97, *P*<0.001). [22]

Assessment of physical activity

Twins responded to a multiple-choice question about what kind of leisure-time physical activities/sports disciplines/exercises they participate in (see online supplementary material). The original Finnish formulation of this question covers both competitive and recreational sports and exercises, and in the current study sport disciplines refers to both kinds. Twenty six common sport disciplines and an open field option were given as response alternatives; multiple sport disciplines could be reported. All sport disciplines were coded separately for the analysis (total of 76 including open-field responses). Then, we calculated the number of sport disciplines participated in, and classified twin individuals into four groups: 1) no sport, 2) 1-2, 3) 3-4, and 4) 5 or more sport disciplines. To further confirm within-in pair associations between discordant twin pairs, we identified all same sex twin pairs (MZ and DZ) in which one twin had participated in five or more sport disciplines and his/her co-twin in at most 2 sport disciplines.

Next, sport disciplines were divided into four groups based on what the participation in that sport principally improves (modified from Aarnio et al. 2002[23] and Sarna et al 1993[24]). “Aerobic”-group consisted of the sport disciplines improving mainly aerobic fitness, “power”-group of sport disciplines improving mainly muscle strength, “mixed”-group of sport disciplines improving both aerobic fitness and muscle strength, and “others” -group of sport disciplines mainly improving something else e.g. skill/technique sports with low or unclear cardio-respiratory or muscular loading intensity. Subsequently, we re-classified the twin individuals to the eight groups covering all the possible combinations of participating in aerobic, power and mixed sports, or not participating in a sport discipline classified in these three groups (see Table 5).

Additionally, we assessed total LTPA volume based on structured questions about the average frequency, intensity, and duration of activity, and the average time used in one day for work journeys. LTPA volume was calculated as average frequency (per month) x duration (min) x intensity (MET), and commuting activity volume as frequency (five times per week) x duration (min) x intensity (4 METs), and the total LTPA volume was expressed as a sum-score of MET hours per day. [12] Validity information is available in detail elsewhere.[22]

Assessment of confounding factors

A dietary guideline adherence (DGA) score was constructed from 11 food-frequency questions and two questions on bread use. Participants estimated how often they usually eat the following food items, considering the past 12 months, with five response options ranging from "not at all" to "many times a day": 1) fruit and berries, 2) vegetables, 3) fish, 4) whole grains (with examples), 5) fast food (with examples), 6) fat free or reduced-fat milk, sour milk or yoghurt, 7) sugar-sweetened soft drinks or juices, 8) energy drinks, 9) butter, 10) margarine, and 11) vegetable oil. Margarine and vegetable oil were combined into one category. In addition, participants were asked how many slices of dark and white bread they usually consume per day, and examples for both bread kinds were given. For each of the 12 food categories, one point was given if the dietary recommendation was met, resulting in a score that ranged from 0 to 12, with a higher score indicating a better dietary guideline adherence and an overall healthier diet. The cut-offs for adherence and non-adherence to each of the 12 dietary guidelines were derived from the most recent Nordic [25] and Finnish nutrition recommendations. [26] As a test of validity, there was a positive correlation between the DGA score and nutrients assessed by 4-day food diaries in 20 male twins, including fibre (r=0.46, *P*=0.04) and energy-adjusted magnesium (r=0.65, *P*=0.002) intake.

A separate multiple adjustment included several potential confounders. Age and number of children were used as continuous variables. Work-related PA (question about how strenuous work or studies are physically), educational level (1. primary and compulsory education (9 years), 2. secondary vocational and academic (up to 12 years), 3. tertiary education (over 12 years) , chronic diseases (reported chronic disease or handicap interfering daily activities; yes/no), alcohol use (frequency of drinking alcohol) and smoking status were used as categorical variables. [12]

Statistical analysis

In individual based analyses data were analyzed using Stata 12.0 (Stata Corp., College Station, TX, USA). The mean values or regression coefficients, and their 95% confidence intervals were estimated by linear regression using the survey analysis estimation methodology, where linearized standard errors account for the sampling design based on twin pair clusters. [27] False Discovery Rate -corrected pairwise comparisons were used to identify mean differences among groups differing for the number of sport disciplines participated in. Chi-square tests were adjusted for the sampling design by using the design-based test statistic of Rao & Scott. [28] Pairwise comparisons between discordant co-twins were performed in SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA). The normality of the variables was assessed with the Shapiro-Wilk test. Normally distributed data were analyzed with two-sided paired-sample t-tests and non-normally distributed data with the Wilcoxon signed-rank test. The level of significance was set at $P < 0.05$.

RESULTS

Characteristics of participants

Characteristics of study participants stratified by gender and the number of sport disciplines participated in (no sport, 1-2, 3-4, 5 or more) are presented in Table 1. LTPA volume and diet quality (DGA score) increased with the number of sport disciplines participated in. Weight and BMI were lower among persons who participated in several sport disciplines. They had as well a physically lighter work-load, and were higher educated. Among women, those who participated in several sport disciplines reported less often having children. Women, who did not participate in sports, or men, who did not participate in sports or participated only in 1-2 sport disciplines reported slightly more often having a chronic disease. Current smoking was the most prevalent among those who did not participate in any sports.

Sport disciplines

Walking, bicycling and jogging were the most popular aerobic sports, while floorball among men and aerobics among women were the most popular mixed sports (Table2). Table 2 also shows the mean WC values by sport. Those not participating in any sport disciplines had the largest WC means, while the individual sports showed a large degree of variation in mean WC values.

A higher number of participated sport disciplines was associated with smaller WC among both genders (Table 3). The linear decrease was 1.38 cm (95% CI 1.10 to 1.65) per each additional sport discipline. Adjusting this result for LTPA volume (1.04cm, 95% CI 0.75 to 1.33), diet quality (DGA score) (0.95cm, 95% CI 0.6 to 1.23), and multiple potential confounders (1.10cm, 95%CI 0.83 to 1.38) did not alter results materially.

Among all discordant twin pairs, twins who participated five or more sport disciplines had 3.3 cm (96% CI *P*=0.034) and 5.2cm (*P*=0.011) in men and women, respectively, smaller WC than their co-twins who participated only in 1-2 sport disciplines or not at all (Table 4). Among only DZ pairs the difference was greater being 4.8cm (*P*=0.033) in men, and 11.2 (*P*=0.003) in women. The significant within-pair differences were also seen in BMI and diet quality in women, but not in men. No differences were seen among discordant MZ pairs.

Types of sports

After re-classifying twins to the eight groups for possible combinations of participation (or no participation) in aerobic, power and mixed sports, all three types of sports were individually associated with smaller WC among (Table 5 and 6). In women, participation in power and/or mixed sports, regardless of participation in aerobic sports, was related to smaller WC. Adjusting the result for LTPA volume, diet quality (DGA score), and multiple potential confounders did not alter results substantially (Table 6).

DISCUSSION

Among young adults in their mid-30s, the number of participated sport disciplines was inversely associated with WC, and also seen by using a discordant twin pair analysis. However, discordant MZ twin pairs did not have difference in WC . Additionally, in men, all three types of sports were individually associated with smaller WC, while in women, only mixed and power sports associated with favourable levels of WC.

Diverse sport participation

According to the intervention trials, aerobic exercise is found to be more beneficial in reducing abdominal fat than strength training. [13] In our observational study, participation only in aerobic sports was less sufficient regarding WC than exercise behaviours including participation in power and/or mixed sports. A recent cohort study showed stronger benefits of strength training on WC growth compared to aerobic exercise[29], as well another study showed that adherence whichever in aerobic or resistance training one year after weight loss intervention prevented regain of visceral fat.[30] The inconsistency in the findings between habitual self-selected PA and intervention trials may be explained by the limited ability of individuals with excess weight to achieve a sufficient aerobic exercise intensity and volume outside of the trial. [31,32] With respect to our sport type categories, of those who participated only in aerobic sports, 38% and 44% of men and women, respectively, reported that in general the average intensity level of their PA was as strenuous as walking (i.e. the lowest intensity level). Therefore, low intensity level of aerobic exercises may explain why aerobic sports alone were not as beneficial in free-living population as could be assumed based on the intervention trials.

Earlier studies of sport disciplines and health have mainly focused on certain sport disciplines at time, and the strongest but limited evidence is found for the beneficial effect of football and running. [16] In the present study, the smallest mean WC had the men who participated in gymnastics, orienteering, basketball, and jogging/running, and the women who participated in yoga, golf, skating/roller-skating, and jogging/running. Men and women who did not participate in sports had the largest WC, followed by those who participated in walking, swimming, and volleyball. Overall, the individual sports showed a large degree of variation in mean WC values, and comparing individual sports to each other is challenging. However, the number of participated sports disciplines was inversely associated to waist circumference. Although the number of sport disciplines participated in correlated with the volume of physical activity (Table 1), the result between waist circumference and number of sport disciplines persisted after adjusting for overall volume of physical activity. In accordance with our findings, Garcez et al.[33] showed that women who had participated in five or more different physical activities in adolescence were less likely to be abdominal obese in adulthood. The benefits of enhancing diverse sport participation may be manifold. From the exercise adherence perspective, Borodulin et al. [34] found that participation in many types of sports in young adulthood was associated with lesser inactivity later in adulthood. Another study among young men showed that participation in several different sports may protect from harmful effects of single risk sport, as from musculoskeletal problems. [35]

Practical considerations

In terms of abdominal obesity prevention, it seems unimportant to limit exercise modes, but rather encourage participation in sports in various ways. In exercise counselling individuals own exercise preferences are in the centre, since individual´s intrinsic motivation is crucial for long-term exercise maintenance. [36] Sport disciplines that are popular in real-life should be in various ways incorporated into future study designs, especially intervention studies that test feasible ways to prevent abdominal obesity. Of note, the associations found in the current study may be two-sided; the participation in certain sport disciplines and sport types may lead to certain body composition, or on the other hand, certain body composition may make it easier to participate in specific sports. It can be assumed, that some sport disciplines are so-called low-threshold sports, such as walking, that are easy to perform without specific equipment or skills, great effort to go to a specific sport place or entrance fees, and thus, may be favoured by occasionally active persons. Similarly, some sport disciplines, such as walking, bicycling and swimming, are most likely easier exercises for persons with excess weight or low physical fitness. Thus, the possibility of the reverse causation between body composition and sports exists as well.

Strengths and limitations

Our analysis among all discordant twin pairs confirmed the inverse relationship between the number of participated sport disciplines and WC, and enabled to control the results for different confounding childhood experiences as twin pairs are usually reared together. We could not replicate the results among discordant MZ twin pairs, which may be due to sharing of the genetic background of sports activity and abdominal obesity seen in twin studies, [18] However, genetic variants associated with BMI or regional adiposity are not correlated with physical activity. So genetic confounding is the less likely explanation, and rather the small number of discordant MZ pairs reduced the power to detect possible differences.. According to the earlier studies, a substantial difference in physical activity volume for longer periods leads to the differences in intra-abdominal fat among MZ twins as well.[37,38] Strength of the current study includes also the possibility to adjust the results for diet quality, and this adjustment did not change the results materially. One limitation of our study is self-reported data, which can lead to reporting bias, but then made large observational data collection with self-measured WC possible. Because of the cross-sectional study design we are unable to make causal inferences. Of note, when interpreting the results, some of the sport disciplines are strongly seasonable (e.g. cross-country skiing). The generalizability of the results is fairly good, as the BMI values of our twins are of similar level or slightly lower compared to the general Finnish population. [39]

Conclusion

Among young adults in their mid-30s, the number of participated sport disciplines was inversely associated with WC, and this association was seen with twin pairs discordant for the number of sports disciplines. In men, all three types of sports (aerobic, power and mixed) were individually associated with smaller WC, while in women, only mixed and power sports associated with favourable level of WC. With respect to exercise counselling, promoting rather diverse sports participation than focusing on specific sports may be beneficial in terms of preventing abdominal obesity among adults in real-life.

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Table 1. Characteristics of the study participants by gender and number of participated sport disciplines

Men, N=1874	A) **No sport** n=105	B) **1-2 sport disciplines** n=733	C) **3-4 sport disciplines** n=595	D) **5 or more sport disciplines** n=441	
Age, mean (SD) (y)	34.2 (1.4)	33.9 (1.2)	34.0 (1.3)	34.0 (1.3)	
Weight, mean (SD) (kg)	86.1 (16.7)^{D}	83.7 (14.7)^{D}	83.3 (13.2)^{D}	81.1 (10.9)^{A,B,C}	
Height, mean (SD) (cm)	178.4 (6.8)	179.0 (6.7)^{D}	179.6 (6.6)	180.2 (6.6)^{B}	
Body mass index, mean (SD) (kg/m^2)	27.0 (4.8)^{C,D}	26.0 (3.9)^{D}	25.8 (3.6)^{D}	24.9 (2.8)^{A,B,C}	
LTPA-volume[a], mean (SD) (MET-h/d)	1.1 (1.4)^{B,C,D}	3.5 (3.3)^{A,C,D}	5.2 (4.2)^{A,B,D}	6.7 (4.6)^{A,B,C}	
DGA score[b], mean (SD)	6.1 (1.8)^{B,C,D}	6.8 (2.1)^{A,C,D}	7.5 (2.2)^{A,B,D}	8.1 (1.9)^{A,B,C}	
					P for trend
Work-related PA, % (n)					<0.0001
Sedentary	26 % (27)	39.4% (288)	49.6% (295)	57.1% (252)	
Standing or walking at work	15.4% (16)	18.9% (138)	23.0% (137)	17.5% (77)	
Light manual work	29.8% (31)	22.4% (164)	14.8% (88)	16.6% (73)	
Heavy manual work	21.2% (22)	13.8% (101)	8.7% (52)	6.6% (29)	
Not working or studying	7.7% (8)	5.5% (40)	3.9% (23)	2.3% (10)	
Educational level, % (n)					<0.0001
Primary	6.7% (7)	4.5% (33)	2.5% (15)	1.6% (7)	
Secondary	71.4% (75)	58.5% (428)	44.9% (267)	39.2% (173)	
Tertiary	21.9% (23)	37% (271)	52.6% (313)	59.2% (261)	
Children, % (n)					0.67
Yes	61.0% (64)	55.1% (403)	54.4% (323)	54.8% (241)	
Chronic diseases, % (n)					0.0007
Yes	22.9% (24)	18.2% (133)	15.0% (89)	10.3% (45)	
Smoking status, % (n)					<0.0001
Current (daily) smoker	44.8% (47)	26.7% (196)	17.3% (103)	10.0% (44)	
Occasional smoker	7.6% (8)	12.1% (89)	13.3% (79)	11.6% (51)	
Quitters	19.0% (20)	23.6% (173)	24.4% (145)	21.1% (93)	
Never smoked	28.6% (30)	37.5% (275)	44.9% (267)	57.4% (253)	
Alcohol use, % (n)					0.12
Daily	10.5% (11)	6.6% (48)	4.2% (25)	2.9% (13)	
1–2 times a week	54.3% (57)	57.2% (419)	59.0% (351)	62.1% (274)	
1–2 times a month	20.0% (21)	20.5% (150)	22.7% (135)	20.4% (90)	
Less than once a month	8.6% (9)	10.0% (73)	8.2% (49)	9.5% (49)	
Never	6.7% (7)	5.7% (42)	5.9% (35)	5.0% (22)	

Women, N=2153	A) **No sport** n=84	B) **1-2 sport disciplines** n=771	C) **3-4 sport disciplines** n=805	D) **5 or more sport disciplines** n=495	
Age, mean (SD) (y)	33.9 (1.3)	34.0 (1.3)	34.0 (1.3)	33.9 (1.2)	
Weight, mean (SD) (kg)	70.7 (17.4)^{D}	67.0 (14.2)^{D}	65.9 (12.7)^{D}	63.9 (9.7)^{A,B,C}	
Height, mean (SD) (cm)	166.0 (5.8)	165.6 (6.0)	165.8 (5.7)	166.4 (5.6)	
Body mass index, mean (SD) (kg/m2)	25.7 (6.0)^{C,D}	24.4 (5.0)^{D}	24.0 (4.4)^{A,D}	23.1 (3.3)^{A,B,C}	
LTPA-volume[a], mean (SD) (MET-h/d)	1.0 (1.2)^{B,C,D}	3.0 (3.2)^{A,C,D}	4.4 (3.8)^{A,B,D}	7.1 (5.0)^{A,B,C}	
DGA score[b], mean (SD)	6.8 (2.0)^{B,C,D}	7.8 (2.0)^{A,C,D}	8.4 (2.1)^{A,B,D}	9.0 (1.8)^{A,B,C}	
					P for trend

Work-related PA, % (n)					<0.0001
Sedentary	35.7% (30)	32.2% (248)	40.3% (324)	47.6% (234)	
Standing or walking at work	16.7% (14)	19.1% (147)	20.3% (163)	25.8% (127)	
Light manual work	25.0% (21)	25.9% (200)	23.0% (185)	18.5% (91)	
Heavy manual work	1.2% (1)	3.1% (24)	2.2% (18)	0.8% (4)	
Not working or studying	21.4% (18)	19.7% (152)	14.1% (113)	7.3% (36)	
Educational level, % (n)					<0.0001
Primary	8.3% (7)	3.2% (25)	1.9% (15)	1.0% (5)	
Secondary	50.0% (42)	48.1% (371)	39.9% (321)	30.6% (151)	
Tertiary	41.7% (35)	48.6% (375)	58.3% (469)	68.4% (337)	
Children, % (n)					0.0005
Yes	67.9% (57)	68.4% (527)	62.4% (502)	56.6% (279)	
Chronic diseases, % (n)					0.04
Yes	27.4% (23)	16.1% (124)	16.8% (135)	14.8% (73)	
Smoking status, % (n)					<0.0001
Current (daily) smoker	32.1% (27)	21.4% (165)	14.9% (120)	7.7% (38)	
Occasional smoker	8.3% (7)	8.6% (66)	8.1% (65)	10.1% (50)	
Quitters	19.0% (16)	21.7% (167)	20.8% (168)	20.3% (100)	
Never smoked	40.5% (34)	48.4% (373)	56.1% (451)	61.9% (305)	
Alcohol use, % (n)					
Daily	4.8% (4)	1.4% (11)	1.2% (10)	0.6% (3)	0.0001
1–2 times a week	34.5% (29)	36.6% (282)	43.0% (346)	41.8% (206)	
1–2 times a month	27.4% (23)	29.6% (228)	28.4% (229)	33.9% (167)	
Less than once a month	23.8% (20)	26.0% (200)	22.0% (177)	15.0% (74)	
Never	9.5% (8)	6.4% (49)	5.3% (43)	8.7% (43)	

Note: Supercripts [A,B,C,D] indicate statistically significant differences (P-value <0.05) between groups differing for the number of sport disciplines participated in

SD, standard devidation; BMI, body mass index, LTPA, leisure-time physical activity; PA, physical activity

[a] LTPA and activity during journeys to and from work expressed as MET-h/day

[b] Dietary guidelines adherence score (0-12 points)

Table 2. The most popular sport disciplines and waist circumference among young adult men and women twins in Finland.

Men N=1874				Women N=2153			
Sport discipline	**Sport type[a]**	**n**	**WC (cm) mean (95% CI)**	**Sport discipline**	**Sport type[a]**	**n**	**WC (cm) mean (95% CI)**
No sport		105	96.8 (93.9 to 99.7)	**No sport**		84	84.6 (81.3 to 87.9)
Walking /Nordic walking	Aerobic	791	93.7 (92.9 to 94.6)	**Walking /Nordic walking**	Aerobic	1618	81.2 (80.5 to 81.8)
Bicycling	Aerobic	696	91.3 (90.5 to 92.2)	**Bicycling**	Aerobic	826	80.1 (79.3 to 80.8)
Jogging/running	Aerobic	693	89.6 (88.8 to 90.3)	**Jogging/running**	Aerobic	721	76.9 (76.3 to 77.5)
Gym training	Power	690	91.0 (90.2 to 91.7)	**Gym training**	Power	611	78.4 (77.6 to 79.3)
Cross-country skiing	Aerobic	446	90.4 (89.5 to 91.3)	**Swimming**	Aerobic	580	82.3 (81.2 to 83.4)
Swimming	Aerobic	359	93.2 (91.9 to 94.4)	**Cross-country skiing**	Aerobic	445	77.9 (77.0 to 78.8)
Floorball	Mixed	333	91.4 (90.4 to 92.5)	**Aerobics**	Mixed	398	78.7 (77.7 to 79.7)
Badminton	Mixed	223	90.7 (89.4 to 92.0)	**Dance**	Aerobic	308	79.0 (77.8 to 80.2)
Football	Mixed	204	90.5 (89.2 to 91.9)	**Gymnastics**	Other	200	79.6 (78.1 to 81.1)
Downhill skiing / snowboarding	Mixed	204	90.5 (89.2 to 91.9)	**Downhill skiing / snowboarding**	Mixed	197	78.4 (76.9 to 79.9)
Skating/roller-skating	Aerobic	189	90.9 (89.5 to 92.2)	**Skating/roller-skating**	Aerobic	171	76.7 (75.4 to 78.1)
Ice-hockey	Mixed	136	91.6 (90.1 to 93.2)	**Horse riding**	Other	138	77.5 (75.9 to 79.1)
Golf	Aerobic	122	89.9 (88.3 to 91.5)	**Yoga**	Other	75	76.0 (74.3 to 77.7)
Tennis	Mixed	104	91.1 (89.3 to 92.9)	**Floorball**	Mixed	67	79.5 (77.5 to 81.5)
Martial art (e.g. Judo, Karate)	Mixed	93	90.5 (88.4 to 92.6)	**Badminton**	Mixed	66	80.7 (78.0 to 83.5)
Volleyball	Mixed	85	92.7 (90.5 to 94.9)	**Golf**	Aerobic	59	76.3 (74.6 to 78.0)
Rinkball	Mixed	54	90.0 (87.9 to 92.1)	**Tennis**	Mixed	50	77.4 (74.5 to 80.4)
Orienteering	Aerobic	54	87.6 (84.9 to 90.3)	**Martial art (e.g. Judo, Karate)**	Mixed	47	80.1 (77.5 to 82.7)
Rowing / canoeing	Aerobic	50	90.2 (87.2 to 93.3)	**Pilates**	Other	47	78.4 (75.2 to 81.6)
Gymnastics	Other	38	87.5 (84.6 to 90.3)	**Volleyball**	Mixed	42	82.5 (79.1 to 86.0)
Basketball	Mixed	34	89.2 (85.8 to 92.6)	**Rowing / canoeing**	Aerobic	37	79.1 (76.0 to 82.1)
Squash	Mixed	34	90.7 (88.3 to 93.1)	**Football**	Mixed	33	79.8 (76.9 to 82.8)
Dance	Aerobic	32	91.2 (87.3 to 95.0)	**Orienteering**	Aerobic	32	77.8 (74.2 to 81.4)
				Indoor cycling /spinning	Aerobic	32	80.0 (75.8 to 84.3)

WC, waist circumference; CI, confidence interval

Sport disciplines with N lower than 30 are not presented in the table.

[a] Aerobic: includes sport disciplines improving mainly aerobic fitness, Power: includes sport disciplines improving mainly muscle strength, Mixed: includes sport disciplines improving mainly both aerobic fitness and muscle strength, Other type of sport: includes sport disciplines improving mainly something else (e.g. skill/technique sports).

Table 3. Number of participated sport disciplines and waist circumference among young adult men and women.

Number of sport disciplines[a]	Men, N=1874		Women, N=2153	
	n (%)	WC (cm), mean (95% CI)	n (%)	WC (cm), mean (95% CI)
1) 0	105 (5.6)	96.8 (93.9 to 99.7)	84 (3.9)	84.6 (81.3 to 87.9)
2) 1-2	733 (39.1)	93.6 (92.7 to 94.4)	771 (35.8)	82.4 (81.5 to 83.4)
3) 3-4	595 (31.8)	92.0 (91.1 to 92.9)	805 (37.4)	80.5 (79.6 to 81.3)
4) 5 or more	441 (23.5)	89.6 (88.7 to 90.4)	493 (22.9)	77.5 (76.7 to 78.3)

WC, waist circumference; CI, confidence interval

[a] Includes all sport disciplines that person reported participating in (also seasonal sports)

Table 4. Waist circumference, body mass index, dietary quality and leisure-time physical activity volume among co-twins discordant[a] for number of participated sport disciplines.

	Men					Women				
		Twin 1	Twin 2				Twin 1	Twin 2		
	Pairs, N	**Mean (SD)**	**Mean (SD)**	**Mean intrapair difference (95%CI)**	***P*-value**	**Pairs, N**	**Mean (SD)**	**Mean (SD)**	**Mean intrapair difference (95%CI)**	***P*-value**
All same sex pairs	55					44				
WC		93.0 (11.6)	89.7 (8.3)	-3.3 (-6.3 to -0.3)	0.034		82.8 (12.9)	77.6 (9.8)	-5.2 (-8.9 to -1.6)	0.011
BMI		25.9 (4.0)	25.1 (3.0)	-0.8 (-1.8 to 0.2)	0.12		24.8 (5.4)	23.4 (4.3)	-1.4 (-2.6 to -0.2)	0.041
DGA score[b]		6.8 (1.9)	7.5 (1.6)	0.7 (0.03 to1.4)	0.064		8.1 (2.0)	9.2 (1.8)	1.0 (0.3 to 1.8)	0.010
LTPA-volume[c]		2.6 (2.6)	5.7 (4.5)	3.0 (1.7 to 4.4)	<0.001		3.1 (3.2)	6.7 (5.5)	3.6 (1.8 to 5.4)	<0.001
Dizygotic pairs	36					20				
WC		94.8 (12.6)	90.1 (7.2)	-4.8 (-91 to -0.4)	0.033		87.2 (13.1)	76.0 (9.0)	-11.2 (-18.0 to -4.4)	0.003
BMI		26.5 (4.3)	25.1 (2.8)	-1.3 (-2.8 to 0.1)	0.065		25.4 (5.4)	22.7 (3.8)	-2.8 (-5.2 to -0.04)	0.025
DGA score[b]		7.1 (1.9)	7.6 (1.7)	0.5 (-0.3 to 1.3)	0.22		7.8 (2.0)	9.3 (1.8)	1.5 (0.01 to 3.0)	0.045
LTPA-volume[c]		3.0 (2.8)	5.8 (4.6)	2.8 (1.0 to 4.6)	0.003		2.0 (1.7)	6.1 (4.3)	4.1 (1.7 to 6.5)	0.002
Monozygotic pairs	19					24				
WC		89.5 (8.4)	89.1 (10.2)	-0.4 (-3.4 to 2.5)	0.77		79.1 (11.7)	78.9 (10.4)	-0.2 (-2.7 to 2.3)	0.87
BMI		24.7 (2.9)	25.0 (3.3)	0.2 (-0.8 to 1.3)	0.63		24.3 (5.5)	24.0 (4.7)	-0.3 (-1.2 to 0.6)	0.53
DGA score[b]		6.2 (2.0)	7.4 (1.5)	1.2 (-0.2 to 2.5)	0.10		8.5 (2.0)	9.1 (2.0)	0.6 (-0.1 to 1.4)	0.11
LTPA-volume[c]		1.8 (1.9)	5.3 (4.4)	3.5 (1.5 to 5.5)	0.002		4.0 (3.8)	7.2 (6.4)	3.1 (0.3 to 5.9)	0.030

SD, standard deviation; CI, confidence interval; WC, waist circumference; BMI, body mass index, DGA, dietary guideline adherence; LTPA, leisure-time physical activity

[a] Twin 1= participated in 0 to 2 different sport disciplines, Twin 2= participated in 5 or more different sport disciplines

[b] DGA score 0-12 points

[c] LTPA and commuting activity expressed as MET-h/day

Table 5. Participation in different types of sports[a] and waist circumference among young adult men and women

Sport type			Men, N=1874		Women, N=2153	
Aerobic	Power	Mixed	n (%)	WC (cm) mean (95% CI)	n (%)	WC (cm) mean (95% CI)
-	-	-	116 (6.2)	96.5 (93.7 to 99.2)	113 (5.2)	83.0 (80.2 to 85.8)
+	-	-	508 (27.1)	94.1 (93.0 to 95.3)	976 (45.3)	82.1 (81.3 to 82.9)
-	+	-	46 (2.5)	93.4 (90.9 to 95.9)	18 (0.8)	77.9 (73.2 to 82.5)
-	-	+	112 (6.0)	92.8 (91.0 to 94.5)	29 (1.3)	78.5 (75.5 to 81.5)
+	+	-	282 (15.0)	91.2 (89.9 to 92.4)	290 (13.5)	79.0 (77.7 to 80.2)
+	-	+	441 (23.5)	91.1 (90.1 to 92.1)	412 (19.1)	80.0 (79.0 to 81.0)
-	+	+	36 (1.9)	92.6 (89.8 to 95.4)	11 (0.5)	81.5 (75.3 to 87.8)
+	+	+	333 (17.8)	90.4 (89.4 to 91.4)	304 (14.1)	77.8 (76.7 to 78.9)

[a] Aerobic: includes sport disciplines improving mainly aerobic fitness, Power: includes sport disciplines improving mainly muscle strength, Mixed: includes sport disciplines improving mainly both aerobic fitness and muscle strength

- No participation in a sport discipline classified in that group

+ Participation in at least one sport discipline classified in that group

Table 6. Linear model of statistically significant sport types predicting waist circumference (cm)

	β	95%CI	*P*-value
Model 1			
Men			
Aerobic	-2.07	-3.49 to -0.66	0.004
Power	-2.98	-4.51 to -1.45	<0.001
Mixed	-3.16	-4.53 to -1.79	<0.001
Power × Mixed	2.36	0.38 to 4.34	0.020
Women			
Power	-2.72	-3.76 to -1.67	<0.001
Mixed	-1.84	-2.82 to -0.87	<0.001
Model 2			
Men			
Aerobic	-1.71	-3.11 to -0.32	0.016
Power	-1.81	-3.34 to -0.28	0.021
Mixed	-2.32	-3.69 to -0.95	0.001
Power × Mixed	2.16	0.19 to 4.13	0.031
Women			
Power	-1.48	-2.59 to -0.37	0.009
Mixed	-0.95	-1.93 to -0.33	0.06
Model 3			
Men			
Aerobic	-1.63	-3.04 to -0.22	0.023
Power	-2.42	-3.91 to -0.92	0.002
Mixed	-2.97	-4.32 to -1.61	<0.001
Power × Mixed	2.19	0.24 to 4.14	0.027
Women			
Power	-2.39	-3.43 to -1.35	<0.001
Mixed	-1.63	-2.26 to -0.66	0.001
Model 4			
Men			
Aerobic	-1.43	-2.86 to 0.01	0.051
Power	-2.64	-4.20 to -1.09	0.001
Mixed	-2.81	-4.19 to -1.44	<0.001
Power × Mixed	2.27	0.29 to 4.25	0.025
Women			
Power	-2.50	-3.55 to -1.45	<0.001
Mixed	-1.37	-2.34 to -0.40	0.006

Model 1: No covariates in the model
Model 2: Adjusted for leisure-time physical activity volume
Model 3: Adjusted for dietary guidelines adherence score
Model 4: Multiple adjustment for age, work-related physical activity, educational level, number of children, chronic diseases, alcohol use, smoking status

Online supplement material 1

What kind of leisure-time physical activities/sports disciplines/exercises do you participated in? (you can choose several sports)

1 Walking/Nordic walking	11 Floorball	21 Golf
2 Jogging/running	12 Football	22 Downhill skiing/snowboarding
3 Bicycling	13 Ice-hockey	23 Horse riding
4 Cross-country skiing	14 Rinkball	24 Orienteering
5 Swimming/water running	15 Volleyball	25 Rowing/canoeing
6 Skating/roller-skating	16 Basketball	26 Martial art
7 Gym training	17 Finnish baseball	27 Other, what?_____
8 Aerobics	18 Badminton	___________________
9 Gymnastics	19 Squash	___________________
10 Dance	20 Tennis	___________________

Note: The original Finnish formulation of this question covers both competitive and recreational sports and exercises