KUOPION YLIOPISTON JULKAISUJA D. LÄÄKETIEDE 292
KUOPIO UNIVERSITY PUBLICATIONS D. MEDICAL SCIENCES 292

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Leisure-Time Physical Activity in Late Adolescence

A Cohort Study of Stability, Correlates and Familial Aggregation in Twin Boys and Girls

Doctoral dissertation

To be presented by permission of the Faculty of Medicine of the University of Kuopio for public examination in Auditorium XIII, University of Helsinki on Friday 13th December 2002, at 1 pm

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KUOPION YLIOPISTO
KUOPIO 2002

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ISBN 951-781-892-0
ISSN 1235-0303

Kuopio University Printing Office
Kuopio 2002
Finland

Aarnio, Marja. Leisure-time physical activity in late adolescence. A cohort study of stability, correlates and familial aggregation in twin boys and girls. Kuopio University Publications D. Medical Sciences 292. 2002. 87 p.
ISBN 951-781-892-0
ISSN 1235-0303

ABSTRACT

Regular exercise has been shown to exert many positive effects on health. Sedentary behaviour often originates in childhood and many common adult chronic diseases are related to inactivity. Adolescent physical activity patterns and health habits are important subjects to study because of the known associations of physical activity with other health habits and the evidence that these associations track into adulthood.

The data for this study were gathered as a part of FinnTwin16, a longitudinal study of five consecutive birth cohorts of Finnish twins, their siblings and parents. The study material was collected by identifying twins born in 1975-1979. Questionnaires concerning leisure-time physical activity, health-related behaviours, social relationship and health status were sent to twins on their 16^{th} and 17^{th} birthdays, and six months after their 18^{th}. The maximal cohort size was 4906 boys and girls, and the response rate 75.8% to 81.7%.

The results of this study reveal that persistently active adolescents smoked less than inactive ones, and usually had better health and nutritional habits, such as use of spreads and regular breakfast eating, and better self-estimated health. They attended high schools rather than vocational schools and tended to have better academic achievement. Participating in organised sport, in many different types of sport, or in power sports and ball games were also associated with persistent physical activity. Parents' and grandparents' physical activity were not associated with adolescent physical activity except in the case of very active mothers and daughters, but a co-twin's physical activity was associated.

There was a gender difference in physical activity patterns: boys were more active than girls. No gender difference was found in health related-behaviours, except that girls reported more psychosomatic symptoms such as tension, in the low physical activity categories than boys.

The known health benefits of physical activity and risk of declining activity during adolescence makes young people at this stage of life an important target group for physical activity promotion programmes. Based on this study, physically active adolescents seem to progress to a healthier and more educated life. Adolescents approaching the completion of their compulsory education and thus the end of their systematic physical education can be considered a particular risk group for inactivity.

National Library of Medicine Classification: QT 250, QT 255

Medical Subject Headings: leisure activities; exercise; health status; food habits; smoking; life style; family health; family relations; adolescence; adolescent behavior; twins; cohort studies

To Sebastian, Hans-Christian and Charlotta

ACKNOWLEDGEMENTS

This study was carried out at the Department of Public Health (KTTL), University of Helsinki, with the co-operation of the Department of Physiology, University of Kuopio. I wish to thank KTTL for the privilege of using the extensive Finn Twin datasets gathered there. This study received financial support from the Ministry of Education for the first years. This support is gratefully acknowledged.

I have been very fortunate to have two excellent supervisors, professor Jaakko Kaprio and docent Urho Kujala. They always found time to read and comment on my manuscript during these years, which in my case involved a lot of time! Their constructive comments, continual support and endless patience have been vital to the success of this study. I also thank docent Heikki Pekkarinen for his encouragement to start this work and his support throughout these years.

The two official referees of the dissertation, docent Olli Raitakari from the University of Turku and docent Sakari Karvonen from Stakes, are gratefully acknowledged for their careful work and constructive criticism that helped to clarify the manuscript during the final stages.

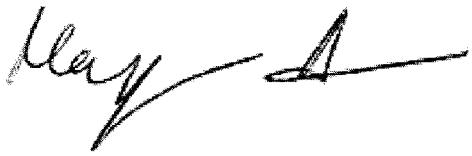
I wish to express my gratitude for all the statistical and technical assistance I have received with this work. Special thanks to Torsten Winter for his time and patience with the statistical analysis, to Lauri Karppinen for helping with the pictures, and to Richard Burton for the language revision. I also thank my Wellmedia colleagues for their support, and for understanding the time this work has taken from my daily work. I particularly thank my business partner Arto Tuominen for his way of motivating me by challenging and endless encouragement during these years.

I am sincerely grateful to all my friends for their encouragement and good company. I especially thank them all for reminding me of the importance of other interests in life.

Warmest thanks go to my family. My parents, Pirkko and Pentti Knuuttila, have shown such confidence in me, along with endless support and interest in my work and

well-being. Their appreciation of my academic studies has encouraged me throughout these years. I am also deeply grateful to Kari for his support, and for sharing with me these most challenging years, and to our wonderful children, Sebastian, Hans-Christian and Charlotta, for being the sunshine of my life.

Helsinki, November 2002



Marja Aarnio

ABBREVIATIONS

AHLS	Adolescent Health and Lifestyle Survey
BMI	body mass index
CI	confidence interval
DZ	dizygotic
MET	metabolic rate for physical activity
MZ	monozygotic
NIC	not included
OR	odds ratio
PA	physical activity
VO_2max	maximal oxygen uptake
χ^2	chi-square

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original articles, which are referred to in the text by Roman numerals I-IV.

I Aarnio M, Kujala UM, Kaprio J. Associations of health-related behaviors, school type and health status to physical activity patterns in 16 year old boys and girls. Scand J Soc Med 1997; 25: 156-167.

II Aarnio M, Winter T, Kujala UM, Kaprio J. Familial aggregation of leisure-time physical activity – a three generation study. Int J Sports Med 1997; 18: 549-556.

III Aarnio M, Winter T, Peltonen J, Kujala UM, Kaprio J. Stability of leisure-time physical activity during adolescence – a longitudinal study among 16-, 17- and 18-year-old Finnish youth. Scand J Med Sci Sports 2002; 12: 179-185.

IV Aarnio M, Winter T, Kujala UM, Kaprio J. Associations of health-related behaviour, social relationships, and health status with persistent physical activity and inactivity: a study of Finnish adolescent twins. Br J Sports Med 2002; 36: 360-364.

CONTENTS

1. INTRODUCTION

Regular exercise has been shown to have a number of positive effects on health. Among adults, higher levels of physical activity have been associated with reduced incidences of cardiovascular disease (Kohl 2001), hypertension (Fagard 2001), low back pain and osteoporosis (Vuori 2001), depression (Dunn et al. 2001), and certain types of cancer (Thune and Furberg 2001). Numerous risk factors for coronary artery disease, hypertension, non-insulin-dependent diabetes and osteoporosis appear to develop in childhood and youth (Williams et al. 1981). Many of the risk factors for coronary heart disease are related to reduced physical activity and sedentary behaviour, both of which commonly originate during childhood (Sallis et al. 1992).

Healthy children are naturally active, but then tend towards inactivity as they grow older (Raitakari et al. 1996). During recent years society in general has become more inactive; for example, children no longer walk to school but take the bus. Physical activity classes have decreased in Finnish schools as a result of economic cutbacks in the 90s. However, whereas habitual physical activity seems currently to be on the decline, participation in organised sport and the amount of time devoted to physical activity increased during the 90s.

The relatively few longitudinal studies of physical activity have found wide variations in the stability of physical activity pattern correlations. According to Kelder et al. in a seven-year follow-up, students identified at baseline with high physical activity tended to remain at this level, as did those with initially low physical activity (Kelder et al. 1994). In a Finnish study of adolescents, however, tracking correlations of physical activity were statistically significant but rather low (Telama et al. 1996).

Health related behaviour and social relationships also seem to be associated with physical activity. Kelder et al. demonstrated in their study some evidence of consolidation and tracking of physical activity, smoking behaviour and food preference (Kelder et al. 1994). Sallis et al. (2000) reviewed 108 studies of physical activity among children (aged 3-12) and adolescents (aged 13-18). Variables that were consistently associated with adolescent physical activity were sex (male), ethnicity (white), age (inverse), perceived activity competence, depression (inverse), previous physical activity, community sports, sensation seeking, sedentary after school and on weekends (inverse), encouragement from parents and others, sibling physical activity, and opportunity to exercise.

What are the factors involved in persisting with physical activity or giving up? According to Telama et al. declining physical activity is associated with the phase of puberty (Telama et al.1994), and pubertual changes might be associated with reduced physical activity (Yang 1997). Also, the gender difference has been pronounced in most studies, boys being more active than girls (Sallis 1993, Hickman et al. 2000, Hämäläinen et al. 2000). As the association of physical activity with other health habits among children and adolescents is known, and there is some evidence that these carry into adulthood, adolescent physical activity patterns, health related behaviour and possible gender differences offer a productive and important field of study.

2. REVIEW OF THE LITERATURE

2.1 Determining and measuring physical activity

The types of physical activity recorded and measurement methods used have varied between studies: from habitual physical tasks (e.g. climbing the stairs, cleaning) to sports club activities, and from direct oxygen consumption measurements to questionnaires.

According to Telama and Laakso (1983) it is important to distinguish between habitual physical activity and that which occurs mainly in leisure time, e.g. in sports clubs. Measurement of physical activity can include frequency, intensity or duration of physical activity. Caspersen et al. (1985) define physical activity as "any bodily movement produced by skeletal muscle that results in energy expenditure". This work concentrates on leisure-time physical activity.

Sirard and Pate (2001) reviewed 59 articles concerned with validating physical activity measurement methods in children and adolescents. They categorised the measures used as primary, secondary and subjective. In this review, direct observation, doubly labelled water and indirect calorimetry were considered the primary standards for assessing physical activity. Heart rate monitors, pedometers and accelerometers were considered as secondary measures, because they provide an objective assessment of physical activity. Finally, surveys, self-report questionnaires, interviews, proxy-reports and diaries were considered as subjective techniques (Sirard and Pate 2001). According to this review direct observation offers the most practical and appropriate measure of physical activity and patterns of activity. Correlations of direct observation with heart rate or oxygen consumption were 0.61 to 0.91. All the primary measures are reliable, but rather expensive and not appropriate for the large scale of epidemiological studies. Special equipment may also be needed. Secondary measurement devices such as heart rate monitors and motion sensors are also useful in physical activity studies.

In epidemiological studies, interviews and questionnaires are the most useful and cost efficient means of measuring physical activity. For example, in a Finnish national survey, the Adolescent Health and Lifestyle Survey (AHLS), a questionnaire for physical activity was used. The frequency of physical activity was measured by asking the amount of time spent in leisure time physical activity and participation in organised sports. The intensity of physical activity was measured by asking about breathing intensity and sweating during physical activity, using five alternatives (Hämäläinen et

al. 2000).

2.2 Distribution of physical activity

Despite a number of studies of physical activity distribution among adolescents in Finland (Raitakari et al. 1994, Nupponen et al. 1997, Yang 1997, Nupponen and Telama 1998), only a few major cohort studies have been carried out. Finnish findings are mainly based on two national surveys, the Adolescent Health and Lifestyle Survey (AHLS) (Hämäläinen et al. 2000), and the pan-European WHO survey (Kannas and Tynjälä 1998).

Trends in physical activity of 12-, 14-, 16- and 18-year-old Finns have been studied in a nationally representative biannual postal survey, the Adolescent Health and Lifestyle Survey, from 1977 to 1999. The questionnaire is sent to Finnish adolescents aged 12-18. The number in the total cohort in 1999 was 70351, and the response rate has ranged from 76% to 88%. Physical activity is measured by frequency, intensity and participation in organised sport (Rimpelä et al. 1999). According to Hämäläinen et al. (2000) the 1999 AHLS survey shows that activity rate (especially sports club activities) decreased with age, while perceived intensity of activity increased. Participation in sports club activities, perceived intensity of activity and the proportion of those reporting very frequent physical activity increased during the study period. Physical activity outside sports clubs remained more common than participation in sport club activities (Hämäläinen et al. 2000).

According to a WHO adolescent survey (Kannas and Tynjälä 1998) the proportion of very active boys increased in Finland between 1986 and 1998. Both time and participation in sports clubs have increased. In general, leisure time physical activity has expanded among adolescents since 1980 (Kannas and Tynjälä 1998, Nupponen and Telama 1998). The proportion of the very active has increased among boys of all age groups.

In a pan-European WHO study, Health and Health Behaviour of Young People, adolescents aged 11, 13 and 15 years were asked how often and how many hours a week they took part in vigorous intensity activity outside school hours. Vigorous physical activity was defined as equivalent to at least slow jogging which might be expected to leave the participant feeling out of breath and sweaty (Hickman et al. 2000). The total number interviewed was 123 227 in 29 European countries, plus USA, Canada and the Russian Federation. The number in the Finnish cohort was 4864. Overall,

students who reported exercising at least twice a week in 1997/1998 were most prevalent in Northern Ireland, Austria, Scotland and Estonia, and in the 15-year-old group also in Germany and the Czech Republic. The most inactive students were from Greenland, Latvia, Lithuania and Hungary. The proportion of students who reported exercising at least twice a week in Finland ranged from 79% to 86% among boys and 64% to 74% among girls across the age groups. The students who reported exercising two hours a week or more were most often from Austria, Denmark, Switzerland and Germany, while those countries with the lowest proportion of adolescents exercising at this level were Latvia, Portugal and the Russian Federation. The proportion of Finnish adolescents in this category ranged from 70% to 76% among boys and 56% to 60% among girls. Finland was also among the most active countries (Hickman et al. 2000).

A gender difference was apparent in both surveys, boys being more active than girls. In the ALHS survey 65% of boys and 55% of girls were participating in physical activity four times a week or more at the age of 12. Perception of being very active declined with age between 12 and 18 years: among boys from 26% to 12% and among girls from 13% to 5%. At the age of 12, 58% of boys and 43% of girls were participating in intense physical activity (sweating and breathing intensely). Very intense physical activity increased from 12 to 18 years: among boys from13% to 43% and among girls from 5% to 17% (Hämäläinen et al. 2000).

According to the WHO survey 82% of boys aged 11-15 in 1998 participated in physical activity at least twice a week, and 52% four times a week; the corresponding proportions in 1996 were 67% and 34%. Among girls in 1998, 68% took physical activity twice and 33% four times a week. In 1996 the corresponding figures were 53% and 18% (Kannas and Tynjälä 1998). In 1998 6% of boys and 11% of girls were inactive. The proportion of inactive youngsters (physical activity less than once a week) decreased between 1996 and1998 among boys, while among girls it varied according to age group (increased among 11-year-olds, stayed the same among 13-year-olds and decreased among 15-year-olds) (Kannas and Tynjälä 1998).

Based on a WHO European survey, Health Behaviour in School Aged Children (Hickman et al. 2000), in most of the countries vigorous activities are more common among boys than girls and decline with age, especially among girls. The gender differences are pronounced in most countries. For example, the proportion of girls exercising vigorously is approximately half that of boys among 15-year-olds in Greenland, Lithuania and Greece (Hickman et al. 2000). Eleven-, 13- and 15-year-old boys and girls are most likely to exercise regularly in Northern Ireland and Austria,

while the lowest proportion doing regular physical activity is in Greenland (Hickman et al. 2000).

2.3 Stability and changes of physical activity

According to Finnish longitudinal studies physical activity reaches its peak between the ages of 12 and 15 years (Nupponen et al. 1997) and then decreases considerably (Telama et al. 1994). Another Finnish study (Raitakari et al. 1994) examined the probability of remaining active or sedentary over the six-year periods from 15 to 21 and from 18 to 24. Among males and females, respectively, 43% and 57% of those classified as active at 15 years were still active at 21, while 54% and 51% classified as sedentary were still sedentary at 21. The corresponding percentages at 18 and 24 years were 54% and 57% active, and 61% and 60% sedentary, in males and females, respectively.

Other Nordic studies have also tended to show that physical activity declines sharply during the early years of adulthood (Andersen and Schelin 1994, Raitakari et al. 1996). In the 1970s a longitudinal Swedish study reported a significant decline in numbers of the physically active, as well as in the amount of physical activity, between the ages of 15 and 20 (Engström 1980).

Sallis (1993) reviewed nine studies employing standardised self-reports or objective measures of physical activity. These studies reveal a consistent decline in physical activity over the school-age years, with the mean level of physical activity decreasing about 2.7 % per year among males and 7.4 % per year among females. Kelder and colleagues' (1994) studies of American adolescents from the 6^{th} to 12^{th} grades found that high activity levels at baseline tended to remain high as the students aged, and that low activity levels at baseline were also persistent. Most of the studies in Table 1 report low to moderate tracking of physical activity.

There have been a few large longitudinal studies in Europe. Malina (1996) compared three major European studies tracking physical activity among Finnish (Raitakari et al. 1994) and Dutch adolescents (van Mechelen and Kemper 1995), and Belgian boys (Vanreusel et al. 1993). Correlations (Pearson or Rank order) under 0.30 were considered low, those between 0.30 and 0.60 moderate, and those over 0.60 high (Malina 1996). Correlations for estimates of physical activity over three-year periods during adolescence were fairly uniform in the three studies, at 0.33 to 0.44, the one exception being Dutch girls with a correlation of 0.58. In the Dutch study, the three-year

correlation in boys for energy expenditure in organised sports was higher than that for physical activity - 0.53 and 0.44 respectively - while the corresponding correlations were essentially the same in girls, at 0.58 and 0.59. Correlations for physical activity over a longer period were much lower for Finnish youngsters (0.18 and 0.17) over the six years from 12 to 18, while the 0.37 correlation in Belgian boys between 13 and 18 did not differ from the 0.35 found between 13 and 16 years. The results of these three studies are generally consistent in indicating low to moderate tracking of physical activity during adolescence (Malina 1996).

It is clear that with increasing follow-up time the tracking correlation drops; in Table 1 those studies with shorter follow-up time have higher tracking correlations. Such correlations are therefore not comparable without taking the follow-up time into consideration.

Table 1. Stability and changes of physical activity. Longitudinal studies tracking physical activity since the 1990s
Correlations (Pearson or rank order) <30 are considered low (+/-), 0.30-0.60 moderate (+) and >60 high (++) (Malina, 1996).

Author	**Country**	**Year**	**Longitudinal follow up**	**Material**	**Methods**	**Results**	**Tracking**
Kelder et al.	USA	1994	7 years Minnesota heart health programme	N= 2376 Baseline 6th grade.	Self-reported physical activity.	Students at baseline reporting high physical activity remained high, and those reporting low PA remained low.	+
Telama et al.	Finland	1994	9 years Cardiovascular risks of young Finns-cohort	N=3596 3-18 years.	Self-reported physical activity.	Physical activity peaked at 12 years and then reduced considerably, but the intensity and strain increased at the same time. Physical activity is a weak predictor of physical activity 9 years later.	+/-
Telama et al.	Finland	1997	12 years Cardiovascular risks of young Finns-cohort	Age 9 (n=610), 12 (n=624), 15 (n=572), 18 (n=503).	Predicted P.A.12 years later. Questionnaire, sum index of 5 variables.	Tracking significant, but low. 9-year internal 0.18-0.47 12-year internal 0.00-0.27 Participation in competitive sport and PE number were the best predictors.	+/-
Yang et al.	Finland	1999	12 year s Cardiovascular risks of young Finns-cohort	N= 2411 Baseline 9,12,15,18 year olds.	Self-reported physical activity.	Early physical activity was the best predictor of adult physical activity with the exception of 21-year- old women.	+
Telama et al.	Finland	1996	12 years Cardiovascular risks of young Finns-cohort	N= 3596 Baseline 3,6,9,12 year old.	Self-reported physical activity.	All tracking correlations significant but low, varying 0.50-0.80 among boys and 0.40-0.61 among girls. Highest tracking correlation was frequency of participation in sports clubs.	+/-

Raitakari et al.	Finland	1994	6 years Cardiovascular risks of young Finns-cohort	N=961	Self-reported physical activity. Sum index from frequency +intensity +duration.	Significant tracking. 3-year sum index correlation ranged 0.35-0.54 among boys and 0.33-0.39 among girls. Physical inactivity showed better tracking than activity.	+
Sallis et al.	USA	1999	20 months	N= 362 boys, 370 girls Baseline 4th and 5th grade	Physical activity computed from child reports, parents' reports and objective activity monitoring.	Significant decline in children's physical activity during 4th and 5th grade. The rate of decline ranged from 3% to 6% for boys and from 7% to 12% for girls.	
Patc et al.	USA	1996	3 ycars Youth risk survey	N=22 boys 25 girls aged 3-4	Hcart ratc measuring: HR over 50% rest pulse between 3-6 p.m.	Spcarman rank ordcr corrclation 0.57-0.66 ($p< 0.001$). Physical activity behaviour tended to track during early childhood.	+
Jantz et al.	USA	2000	5 years Muscatine study	N=126 Mean age 10.8 boys and 10.3 girls	Physical fitness measured by oxygen uptake and maximal isometric contraction, Physical activity measured by questionnaire.	Tracking of physical fitness and activity variables was moderate to high. Sedentary behaviour tracked better in boys, and vigorous activity in girls.	+
Anderssen	Den-mark	1996	7 years	Aged 18-30 at baseline. N=2328 men and 2787 women	Questionnaire four times in the follow-up period.	Moderate tracking. Intraclass correlation 0.57 (0.42-0.57). PA declined sharply during early adulthood.	+
Van Mechelen et al.	Nether-lands	2000	15 years Amsterdam Growth Study	98 female 83 male aged 13, 14, 15, 16, 21, 27	Structured interview. Physical activity over 4METs.	Significant decline of habitual physical activity among males and females between 13 and 27 years.	

Kemper et al.	Nether-lands	2001	20 years Amsterdam Growth Study	400 boys and girls	Physical activity measured by cross check interview.	Stability coefficients 0.35 –0.29.	+/-
Dovey et al.	New Zealand	1998	12 months before turning 15 and 18	775 boys and girls	Interview.	Total participation at the age of 18 was 63% of that reported at 15 years. Boys spent significantly more time in physical activity than girls.	
Armstrong et al.	UK	2000	3 years	202 boys and girls	Annual measurement: HR, body mass, skinfold thickness.	PA decreased from 11 to 13 years, specially among girls.	

PA physical activity
PE physical education

2.4 Correlations with other measures of sport

In Finland, participation in organised sports or sports clubs is a long and very popular tradition among adolescents. According to Kannas and Tynjälä (1998), 47% of boys and 32% of girls aged 11-15 were participating in organised sport in Finland. Between 1986 and 1998 there were no significant differences in participation rates for organised sports among boys, but among 15-year old girls participation decreased significantly. It is interesting that this same study found that participation in physical activity in general increased over the same period (Kannas and Tynjälä 1998). Participation in organised sport varies across European countries: among boys in the 6^{th} class it varies between 21% and 70%, and in the 8^{th} class from 13% to 64%, while the corresponding ranges among 6^{th} and 8^{th} class girls are 16% to 48% and 11% to 43% (Kannas and Tynjälä 1998). Finnish adolescents are the third most active in each age class (Kannas and Tynjälä 1998).

Adolescent physical activity is heavily promoted in Finland by individual organisations within the Finnish Sports Federation (Nuori Suomi /Young Finland), which receives government support. According to Nuori Suomi most adolescents are independently active outside home, either alone or with friends. Second comes membership of a sports club; in Finland 350 000 3-18-year-old children and adolescents belong to a sports club. The most popular sports, depending on age and the type of questionnaire used, are jogging, walking, swimming, football and floorball (hockey played indoors) (Nuori Suomi). There are gender disparities in preferences for sports. Boys tend to participate more in football, ice-hockey, floorball, basketball, weight lifting, and track and field, while girls prefer jogging, walking, riding, gymnastics, slalom and aerobics (Nupponen and Telama 1998).

Playing organised sport has an important influence on physical activity later in life. Participation in competition sports (Telama and Yang 1997) and membership of a sports club (Barnekow-Bergkvist et al. 1998) are predictors of later physical activity, but the best predictor is the student's school grade for physical education, and participation in organised sports (Telama et al. 1994). According to Telama et al. (1996) the highest tracking correlation was for frequency of participation in sports clubs, with the correlation varying from 0.40 to 0.78 among boys and from 0.28 to 0.64 among girls. This may be because the stability of non-organised physical activity appears to be lower than that of organised sports, as it is more difficult to estimate and remember non-organised activities (Telama et al. 1996).

2.5 Correlations of health-related behaviours, social relationships and health status with physical activity

Associations of health related behaviours, social relationships and health status with adolescent physical activity have been studied in several countries. There is evidence of an association between physical activity and health-related behaviours among both adolescents and adults. Sallis et al. (2000) reviewed 108 studies of physical activity among children (aged 3-12) and adolescents (aged 13-18). They found 48 variables for adolescents, and 60% of all reported associations with physical activity were statistically significant. Variables that were consistently associated with adolescent physical activity were sex (male), ethnicity (white), age (inverse), perceived activity competence, intentions, depression (inverse), previous physical activity, community sports, sensation seeking, sedentary after school and on weekends (inverse), encouragement from parents to exercise, sibling physical activity, direct help from parents, and opportunity to exercise.

This review focuses on those health-related variables shown to be related to physical activity among adults and adolescents, and that are predictors of morbidity and mortality, in particular from cardiovascular diseases.

Associations of smoking with physical activity

Among adolescent health-related behaviours, the association of smoking and physical activity has been studied most. The findings tend to be similar: in most of the studies smoking is associated with less physical activity and regular physical activity with non-smoking. The results seem to be similar among adults (Laaksonen 2002). Cross sectional studies among adolescents show that smoking is associated with low physical activity (Escobedo et al. 1993, Donato et al. 1997, Page et al. 1998, Yang et al. 1999). In their study of 11631 US adolescents, Pate et al. (1996) also found an association of smoking with low physical activity. According to longitudinal studies non-smoking is strongly associated with physical activity (Kelder et al. 1994, Pate et al. 1996). For example, Raitakari et al. (1994) found physical activity to be related to less smoking among boys and girls, while Yang in a 12-year follow-up found that non-smoking men and women had a higher level of physical activity than smokers (Yang et al. 1999).

Association of other health-related behaviours and health status with physical activity

The association with physical activity and other health behaviour is an important area of study. Sallis in his review of 108 studies found no association between either alcohol consumption or healthy diet with physical activity (Sallis et al. 2000). Nyström (1998) found that skipping breakfast clustered with other risk factors such as smoking and inactivity. Pate et al. (1996) found in a nationally representative survey of 11 631 US students that low physical activity behaviour was associated with several health related behaviour, such as smoking and lower fruit and vegetable consumption. However, this pattern was not consistent for all health behaviours. Low physical activity was found to be unrelated to self-perception of weight, and was positively associated with alcohol consumption only among female students (Pate et al. 1996). There were also differences between race/ethnic groups, suggesting that sociocultural factors may affect the relationship between physical activity and some health behaviours. De Bourdeaudhuij and van Oost (1999) studied the association of physical activity with other health-related behaviours. The study used cluster analyses and the material was divided into healthy and unhealthy groups within three age groups. Health-related items were alcohol consumption, smoking, sleeping, BMI, and work activity. The correlations between physical activity and the health-related items were low. The highest correlations with physical activity in the 16-25-year age group were for smoking and alcohol consumption, but in all three age groups physical activity seemed to be a unique factor contrasting with other health-related behaviours (De Bourdeaudhuij and van Oost 1999). An association with alcohol consumption was only found in some ethnic groups, suggesting that sociocultural factors may affect the relationships between physical activity and some health behaviours.

The Amsterdam Growth and Health Longitudinal study found that although adolescent physical activity was not related to adult cardiovascular health status, physical activity was directly associated with serum HDL-cholesterol levels (van Mechelen et al. 1999) and lower consumption of saturated fatty acids (Raitakari et al. 1994). According to Yang et al. (1999), early physical activity and current social and health-related behaviours were significantly related to the level of adult physical activity.

Associations of social relationships with physical activity

Associations with social relationships, such as school type, school grades and socioeconomic status, have been less studied. There are also associations between

patterns of physical activity and type of school, school grades - especially in physical education (Telama et al. 1994) - and participation in organised sport (Telama et al. 1994,1997). In a Danish study high school students participated more in leisure time sport and had better physical performance than students from technical or vocational schools (Andersen and Schelin 1994), but according to Telama and Laakso (1983) differences in physical activity by type of school were not strong in Finland. High occupational and employment (being a student) status were predictors of adult physical activity (Yang et al 1999). Vilhjalmsson and Thorlindsson (1998) found in a sample of 1131 15-16-year-olds in Iceland that male sex, sociability, perceived importance of sports and health, and improvement and satisfaction with mandatory gym classes in school were all related to more involvement in leisure-time physical activity, whereas hours of paid work and television viewing were related to less activity (Vilhjamsson and Thorlindsson 1998).

Longitudinal studies show that certain social and environmental factors may predict consistent physical activity. These include higher school grades and participation in organised sports (Telama 1994), and playing sport for school (Dovey et al. 1998), as well as social relationships (Yang et al. 1999), the adolescent's local environment (Telama et al. 1994), and very good self-assessed health (Dovey et al. 1998). The studies of correlations between smoking, other health-related behaviours and physical activity are seen in Table 2.

Table 2. Correlations between smoking, other health-related behaviours and physical activity.
(+ positive association, +/- weak association,- no association)

Author	**Year**	**Country**	**Study design**	**Material**	**Methods**	**Results**	**Association**
Kelder et al.	1994	USA Minnesota heart health programme	7-year follow-up	N=2376 Baseline 6th grade	Self-reported smoking and food choices (Questionnaire).	Smoking: As students began to experiment with smoking, they were more likely to either begin or remain regular smokers. Food choices: Students with high PA at baseline remained high and with low PA at baseline remained low.	Smoke + Diet +
Raitakari et al.	1994	Finland Cardiovascular risks of young Finns-cohort	6-year follow-up	N=900 Baseline 12,15,18 year-olds	Self-reported physical activity. (Questionnaire) Sum index from frequency + intensity + duration.	Physical activity was related to less smoking in both sexes and among young men to lower saturated fatty acid ratio in the diet.	Smoke + Diet +
Yang et al.	1999	Finland Cardiovascular risks of young Finns-cohort	12-year follow-up	N=2411 Baseline 9,12,15,18-year -olds	Questionnaire.	Non-smoking men and women had higher levels of physical activity than smokers.	Smoke +
Escobedo et al.	1993	Portugal	Cross sectional	N=11248 high school students, grades 9-12	Questionnaire.	Students who had participated in interscholastic sports were less likely to be regular and heavy smokers.	Smoke +

Donato et al.	1997	Italy	Cross sectional	N=1462, grades 9-13	Questionnaire.	Smoking was negatively associated with regular sports activity among 12^{th}-13^{th} grade students.	Smoke +
Pate et al.	1996	USA Youth Risk Survey	Cross sectional	N=11 631 US high school students aged 12-18	Questionnaire.	Low activity was associated with smoking, and with alcohol in some ethnic groups.	Alcohol + Smoke +
De Bourdeaudhuij and van Oost	1999	Belgium	1-year follow-up	N=2400, aged16-25	Questionnaire.	Alcohol and smoking were associated with PA in 16-25-year-olds.	Smoke + Alcohol +
Terre et al.	1990	USA	Cross sectional	N=1092, grades 6-12	Questionnaire.	Alcohol use clustered with dislike for leisure time PA in grades 7-8.	Alcohol +
Blank et al.	1993	USA	Cross sectional	N=1 198 students, average age 20.7	Questionnaire.	80.1% of regular exercisers currently used alcohol.	Alcohol +
Lee et al.	2002	USA	Cross sectional	N=8165 students, aged 12-21	Questionnaire.	Low socio-economic status was associated with low physical activity.	SES +
Daley and Ryan	2000	UK	Cross sectional	N=232, aged 8-11	Questionnaire.	No association was found between academic performance and physical activity.	

2.6 Familial aggregation of physical activity

From a theoretical point of view, socialisation into sport and physical activity may be considered a modelling process for which family members are powerful role models. Most, but not all studies reveal that both parents' exercise patterns and encouragement have an effect on children's exercise behaviour, and that physically active parents tend to have physically active children (Telama and Laakso 1983, Klesges et al. 1984, Gottlieb and Chen 1985, Godin et al. 1986, Sallis et al. 1988 and 1992, Anderssen and Wold 1992, Stucky-Ropp and Delorezo 1993, Shropshire and Carroll 1997, Sallis et al. 1999).

Results of studies of parental impact on adolescents' physical activity patterns vary tremendously. Findings from comparing the association of fathers' or mothers' activity with adolescent physical activity are also contradictory. According to Rossow and Rise (1994), fathers' physical activity was positively associated with their adolescent's physical activity, but mothers' physical activity was not. Yang et al. (1996) reported similar results from their 12-year follow-up study, in which fathers' physical activity was associated with their adolescent's physical activity in the same year and was a significant predictor of boys' and girls' physical activity 12 years later and for boys even longer. Lau et al. (1990) reported no significant association between the physical activities of mothers and their adolescents. The studies are seen in Table 3.

Gottlieb and Chen (1985) found that parental exercise had a stronger influence on the frequency of exercise among girls than boys, but according to a study of Finnish school children (Telama and Laakso 1983) both parents' sports activities were correlated with boys' sports activities, but not with girls'.

In general, there seems to be a significant association with family members' and friends' physical activity. The WHO cross-national study on health behaviours among 11-, 13- and 15-year-old adolescents in 10 European countries indicates that when three or more significant persons (family members or best friends) take part in physical activity, 84% of boys and 71% of girls are involved in sport twice a week or more (Anderssen and Wold 1992). When none of these significant others is involved in physical activity, only 52% of boys and 30% of girls report being active in sport.

The present review does not take into consideration the genetic influence in familial aggregation of physical activity or the causality of friends' leisure time physical activity, because it is too large an issue and needs further study. Family members share both genetic background and environment, and friends only the environment. Physical

activity is very much a social activity in adolescence. Young people tend to perform these activities together, and it is consistently shown that physically active adolescents have friends who are also active (Anderssen and Wold 1992).

Table 3. Studies concerning familial aggregation of physical activity. (+ positive association, +/- weak association,- no association)

Author	**Year**	**Country**	**Study design**	**N**	**Methods**	**Results**	**Parental influence**
Moore et al.	1991	USA	1 year follow up	100 children aged 4 to 7 99 mothers 92 fathers	Monitoring with caltrac accelometer	Child of an active mother is 2.0, of active father 3.8, and of active both parents 5.8 times more likely to be active than inactives child.	+
McMurray et al.	1993	USA	Cross sectional	1,253 families	Parents: questionnaire of Exercise benefits and barries scale (EBBS) Children's self report activity, maximal oxygen uptake.	Parents' EBBS was weakly associated with childrens VOmax: mother's was, but father's not. Childrens' questionnaire was not correlated with parents EBBS.	mother+ father -
Stucky-Ropp et al.	1993	Colombia	Cross sectional	242 children in 5^{Th} or 6^{th} grade and their mothers	Interview.	Mother`s perceived family support was correlated with children's physical activity.	+
Telama et al.	1994	Finland	Longitudinal 9-year follow-up	3596 aged 9-18	Questionnaire.	Parents interest correlated positively with children's physical activity.	+

Yang et al.	1996	Finland	3-year follow-up	1881 boys and girls aged 9-15	Questionnaire. Self reported physical activity.	Children's participation in sports was greater in families with active rather than passive parents.	+
Shopshire et al.	1997	USA	Cross sectional	924 boys and girls aged 6	Questionnaire.	Children's physical activity could be attributed to the fathers's, but not mother's physical activity.	father+ mother-
Sallis et al.	1999	USA	Cross sectional	1504 parents and children grades 4-12	Telephone interview.	Family support for physical activity was one of three strong variables associated with physical activity.	+
Rossow et al.	1994	Norway	Cross sectional	337 families	Interview with both parents and adolescent.	Father's physical activity was associated with adolescent's PA, but mother's not.	father+ mother-

3. AIMS OF THE STUDY

The aims of this study were:

1. To describe physical activity patterns among 16-, 17-, and 18,5-year-old Finnish adolescents.

2. To describe the stability of physical activity over three-year period.

3. To examine the association of physical activity with health-related behaviours, social factors and health status.

4. To investigate familial patterns of physical activity.

5. To describe gender differences in physical activity patterns.

4. MATERIAL AND METHODS

4.1 Material

The data for this study were collected in association with FinnTwin 16, a longitudinal study of five consecutive birth cohorts of Finnish twins, their siblings and parents (Kaprio et al. 1990, Rose et al. 1999). The study is a Finnish-American collaborative study mainly funded by the National Institutes of Health of the USA and the Academy of Finland.

The FinnTwin16 study material was collected by identifying twins born in 1975-1979 and their parents from the Central Population Registry of Finland. The baseline assessment was made within two months of the twins' 16th birthdays. It included a survey of health related behaviour and attitudes, a symptom check-list, and relationships with parents, peers and the co-twin.

To 16-year-old twins born in 1975-1979 the questionnaire was mailed in 1991 through to1995. Parents were also sent a questionnaire with the same types of questions. It also included items concerning the maternal and paternal grandparents' related behaviour, leisure time physical activities and socio-economic status.

Two further questionnaires were sent to all twins who replied at the age of 16. One was sent a month after their 17th birthday, and another about six months after their 18th birthday (mean response age 18.5 years). The fourth wave of assessment of the twins is ongoing in 2000-2002.

This thesis is based on four articles (I, II, III, IV), and the material were based on the FinnTwin 16 cohort study (Figure 1a, 1b). The number of twins varies between the articles because the total follow-up data are collected in five-year periods, and in the first articles the available data are based on the material collected over a three-year period. The first article (I) is based on the questionnaire sent to twins on their 16th birthday in 1991-1993. The article explores the association of physical activity at the age of 16 with health-related behaviours, social relationships and health status. The kind of school attended after the end of compulsory education is an extra item based on the 17-year questionnaire, because compulsory universal schooling ends at the age of 16. During this three- year period, 1858 families of twins (boys or girls) were contacted and the total number of individual twins who answered was 3254 (girls n=1697, boys n=1557). The response rate was 91% for girls and 85% for boys (I). The second article (II) concentrates on familial aggregation of physical activity. Information about parents'

and grandparents' physical activity was based on the questionnaire sent to families and twins at the age of 16. The number of families with both parents was 1667 and the response rate among parents was 79% (II). Leisure-time physical activity was assessed using different questions for adolescents, parents and grandparents. Whole families consisted of a pair of adolescent twins, father and mother and four grandparents.

The third (III) article studying the stability of physical activity and types of sport was based on a questionnaire sent to twins at their 16^{th}, 17^{th} and 18.5^{th} birthday. The stability of physical activity was based on all three questionnaires, and the types of sport on the questionnaire sent at the age of 17.

The fourth article (IV) studied the association of health-related behaviours, social relationships and health status with persistent exercise and persistent inactivity, as defined using information from all three questionnaires. The information concerning stability of physical activity was based on all three questionnaires; health-related behaviours and health status were based on the questionnaire sent at the age of 16, and school type on the questionnaire sent on the17^{th} birthday. The number of subjects answering all three questionnaires totalled 5028 (2311 boys and 2717 girls), with a response rate among boys of 75.8 % and among girls of 81.7% (III, IV). Of these, 122 twins (57 boys and 65 girls) were excluded because of incomplete answers or due to an illness or handicap that could affect physical activity. The final cohort size was 4906 subjects (2254 boys and 2652 girls) (III, IV).

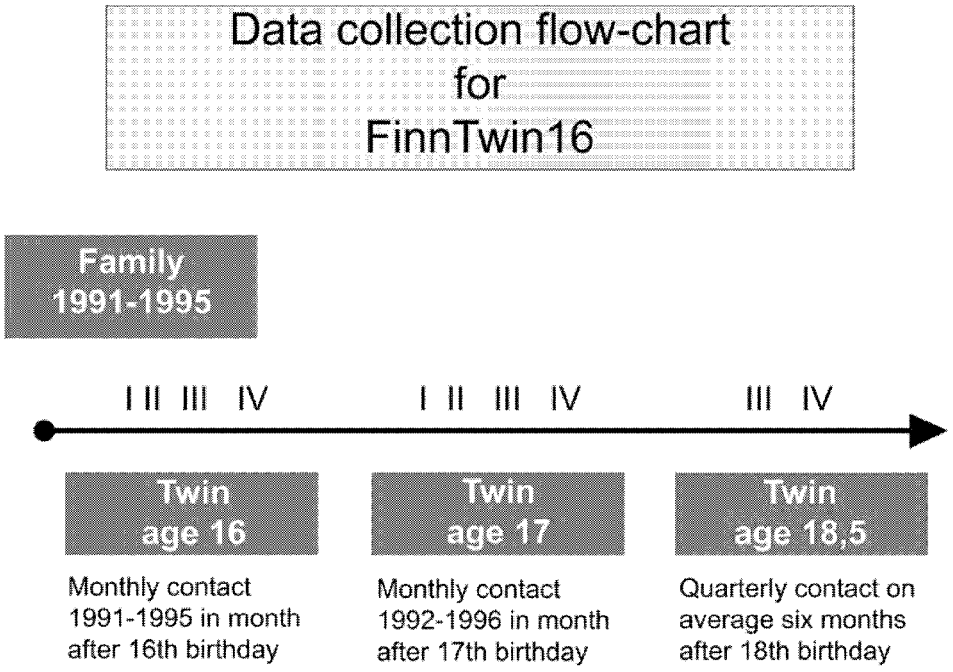


Figure 1a.

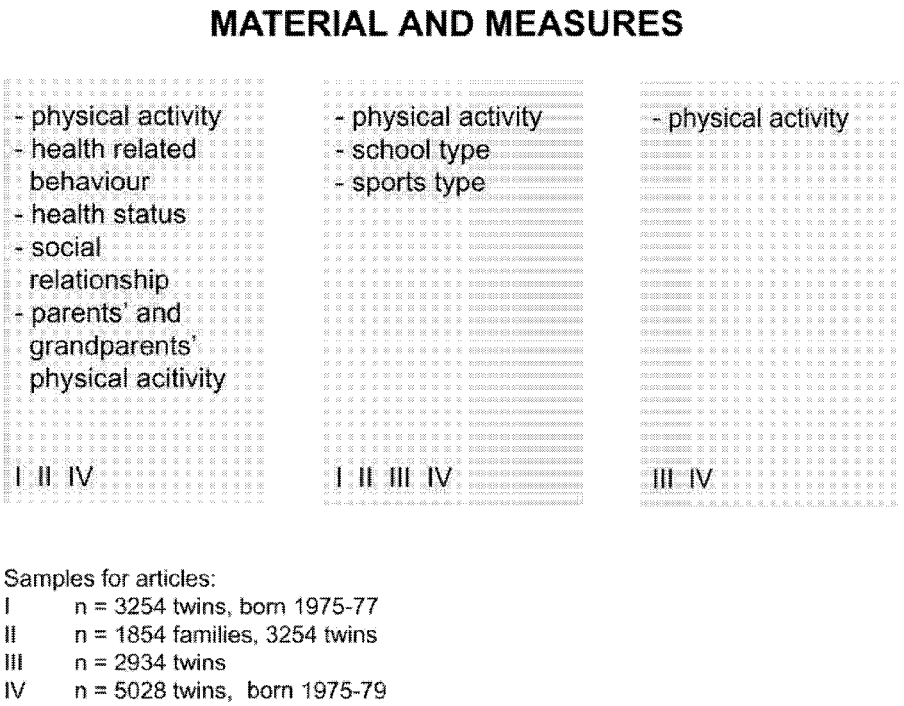


Figure 1b.

4.2 Measures

4.2.1 Physical activity and sports participation

Adolescent physical activity at the age of 16 (I, II)

Two questions were used to measure physical activity. (All items are presented in the first article.) The first question asked the *frequency* of leisure-time physical activity outside of school, with seven response alternatives (not at all, less than once a month, 1-2 times a month, about once a week, 2-3 times a week, 4-5 times a week, about every day). The second question asked about the *intensity* of physical activity, with five response alternatives (profuse sweating and breathlessness, moderate sweating and breathlessness, little sweating and breathlessness, no sweating and breathlessness, no leisure time physical activity). Based on these two questions we formed five physical activity groups in article I, as follows:

The *very active* group: exercise 4-5 times a week or more with profuse or moderate sweating and breathlessness. The *active* group: exercise 2-3 times a week with profuse or moderate sweating and breathlessness, or exercise 4-5 times a week or more with little sweating and breathlessness. The *moderately active* group: exercise 4-5 times a week or more with no sweating and breathlessness, or 2-3 times a week with little or no sweating and breathlessness, or once a week with profuse, moderate or little sweating and breathlessness. The *hardly active* group: exercise 1-2 times a month or less than once a month with profuse, moderate or little sweating and breathlessness, or exercise once a week, 1-2 times a month or less than once a month with no sweating and breathlessness. The *inactive* group: exercise less than once a month or not at all and no leisure time physical activity.

We also asked *own perception of physical fitness* with five alternative answers (very good, rather good, satisfactory, rather poor, very poor).

Stability of adolescent physical activity (III, IV)

We created two variables to describe the stability of physical activity. Those who answered in all three questionnaires (at 16, 17 and 18.5 years) that their frequency of physical activity was 4 to 5 times per week or more formed the "persistent exerciser" group (yes/no), and those exercising less than 1-2 times a month formed the "persistently inactive" group (yes/no).

Other measures of adolescents' sports (III)

In the questionnaire for the 17-years-olds the subjects were asked what types of sport they had participated in. Nineteen alternatives were listed, and they were given the option of reporting any other sports as well. More than one sport could be reported, and all responses were coded and entered separately. They were also asked if they participated or competed in organised sports. We divided the sports into three groups: biking, jogging, cross-country skiing and swimming formed the "aerobic" group; weight lifting and gym-training formed the "power" group; and all other types of sports (slalom, aerobics, gymnastics, tennis, football, volleyball, badminton, baseball, basketball, rinkball, ice-hockey, and skating) formed the "others" group.

Because subjects could be active in more than one sport, we used these three sport groups (aerobic, power and others) to form eight different potential combinations. We then studied the distribution of subjects in these combinations, and the proportions of persistent exercisers and persistently fit subjects therein. Finally, we divided adolescents into those who participated in ball games (football, volleyball, badminton, tennis, baseball, basketball, rinkball, ice-hockey) and those who did not. We also compared those who took part in organised sports with those who did not to assess the social aspects.

Parental and grandparental physical activity (II)

To make the different generations comparable, we developed indices of physical activity. We classified physical activity into five classes reflecting the distribution of physical activity in the parental and twin generations, and three categories for the grandparental generation. The highest and lowest classes in each generation thus correspond to the most active and inactive subjects of that generation. A detailed description of these measures is given in article II.

Parents' physical activity

As the parental questionnaire was revised in April 1993, the data on parental physical activity were derived from two slightly different questionnaires. The physical activity groups were thus based on two versions of the questionnaire, although their aims were identical and they differed from each other only structurally. Both included questions about the type, intensity and amount of physical activity (II).

The intensity of physical activity was measured by estimated MET (metabolic rate for physical activity) values. Walking was estimated as 3 METs, rapid walking and a

mixture of walking and jogging as 6 METs, light jogging as 10 METs, and running as 13 METs (Ainsworth et al. 1993).

Total MET values were calculated in the first questionnaire by multiplying the time used in physical activity (using the class midpoints) by the estimated MET value and adding the four values together. In the second questionnaire, total MET values were calculated by multiplying the estimated MET value by the duration of one physical activity session and the duration of physical activity per month using the class midpoint, and then dividing by four to obtain weekly values. If the subject answered 'not participating in any leisure time physical activity' the estimated MET value was 0.

Mothers' and fathers' total MET values were classified into quintiles (20% of subjects in each class). Those who answered the first or second versions of the questionnaire were classified separately. The mean age of mothers and fathers was equal with both questionnaire versions. Classifications of physical activity in both questionnaires were then combined. The highest 20% were considered as very active and the lowest 20% as inactive. In some analyses parents in these extreme classes were compared with adolescents' physical activity (II).

Grandparents' physical activity

The physical activity of each grandparent was measured by the response provided by the parents (their children). The questions measured whether the maternal and paternal grandparents had had any leisure time physical activity (regular leisure time activity, every now and then but not regularly, no leisure time physical activity, I can't say) during their adult life. Based on these questions grandparents were classified into three categories: active, moderately active, inactive (II).

4.2.2 Health-related behaviours, social relationships and health status (I, II, IV)

For this analysis we selected those items of the questionnaire known to be related to physical activity for adults and adolescents, and which predict morbidity and mortality, in particular from cardiovascular diseases.

Weight was asked to the closest kilogram and *height* to the closest centimetre. Body mass index (BMI) was computed as weight (kg) / height (m2). *Use of dietary fats* was measured by eliciting the types of spread the subjects use on their bread. In the present study, a detailed dietary history could not be taken.

Breakfast eating habits were also measured with a single question using three alternatives (once a week, 3-4 times a week, daily).

Smoking habits were measured by responses to three questions: on smoking initiation, the amount of cigarettes ever smoked and current smoking habits. Based on these questions four different classes of smokers were formed: (1) *non-smokers,* (2) *occasional smokers,* (3) *regular smokers,* and (4) *quitters.* Subjects who had smoked one cigarette at most or had never smoked were assigned to the *non-smokers* class. Those who had smoked a total of 2-50 cigarettes but had never regularly smoked, and subjects who had smoked at least one cigarette or smoked less than once a week were assigned to the *occasional smokers* class. Subjects who reported having smoked 2-50 cigarettes or more during their lifetime and currently smoked at least once a week were assigned to the *regular smokers* class. Subjects who reported that they had quit smoking were assigned to the *quitters* class. Subjects with contradictory answers were excluded from the classification (girls 0.4 %, boys 1.7 %).

Alcohol consumption was measured by three questions: on the frequency of alcohol consumption, the frequency of times intoxicated, and the frequency of slight intoxication. Based on the responses to these questions alcohol use was classified into three categories: (1) *non-users*, (2) *users*, and (3) *heavy users.* Subjects who drank alcohol once a week or more or were drunk at least once a month or slightly intoxicated at least once a week were considered *heavy users* for their age. Subjects who did not use alcohol and never got even slightly intoxicated belonged to the *non-users* class. If answers corresponded to other alternatives, subjects were considered to belong to the *users* class.

Social relationships (I, II, IV)

Social relationships were assessed with three questions. Two concerned whether the subjects were *working, attending school*, or doing something else, and on what *type of school* they attended. Compulsory education in Finland is completed in the year the adolescent turns 16. Hence, those responding in the spring are generally still at comprehensive school, but typically continue on to high school or vocational school. The main alternative to high school at the age of 16 is vocational school, which is less academically oriented. The third question concerning social relationships queried with whom they spent their *leisure time.* In the case of multiple responses, the response was classified according to the size of the group, i.e. the largest group with which they spent their time.

Parents' socio-economic status (II, IV)

We also took into consideration parents' socio-economic status when assessing familial associations of physical activity. The classification of socio-economic status was based on the parents' current and former occupation. The parents' occupational mobility was not taken into account. However, because only about 15 % of mothers and 6% of fathers were younger than forty, there is unlikely to be any large shift in socio-economic status due to further education. Present employment (employee vs. self-employed) and education were also taken into account. The coding into socio-economic groups was done according to the Finnish Central Statistical Office's (1987) classification. The classifications were structurally different in the second and fourth article.

The main socio-economic categories in the second article were self-employed persons, upper-level employees with administrative, managerial, professional and related occupations, lower-level employees with administrative and clerical occupations, manual workers, students, pensioners, and others. In the fourth article the categories were combined into upper-level employees, lower-level employees, workers (manual workers, pensioners, unemployed), self-employed, and farmers. More detailed descriptions appear in articles II and IV.

Health status (I, IV)

Subjects were asked to indicate their *perception of their current health,* and the *presence of long- term illness* hindering daily activity. *Psychosomatic symptoms* were assessed with ten questions on different symptoms, asking their frequency. The minimum summed symptom score was 10 (if choosing the first alternative for all symptoms) and the maximum 40 (if choosing the fourth alternative for all symptoms). Cronbach's reliability coefficient was .73 among both girls and boys for this sum score.

(All questions appear in the appendix).

4.3 Data analysis and statistical methods (I, II, III, IV)

The study variables were first examined by cross tabulations in all articles (I, II, III, IV). The chi-square test was used to test the differences in distributions in the frequency tables, while differences in means (for continuous variables) were tested by the t-test, or

by analysis of variance or covariance procedures.

Log linear models were used to analyse the simultaneous relationship of physical activity to several categorical variables. Thus, in the first article, a log-linear model with terms for all two-way interactions between physical activity, sex and independent variables were fitted first. Then the three-way interaction was fitted and the change in model fit relative to change in degrees of freedom was used as the statistical test (I).

In the second article, to assess familial aggregation of physical activity, intra- and intergenerational correlation coefficients were computed between relative pairs.

In the third article, Spearman correlations were used to assess the strength of associations between ordered variables, while odds ratios and their 95% confidence intervals (OR, 95 % CI) were used correspondingly for pairs of dichotomous variables (III).

In the fourth article, the associations between persistent physical activity and health-related behaviours and other determinants were assessed by logistic regression analyses, which were used to screen which variables showed significant associations with the outcome measures, first individually and then by multivariable analysis within groups (health-related behaviours, social relationships and health status). A final sex-specific logistic regression was done with those variables that remained significant. The possible lack of statistical independence between members of a twin pair was taken into account by using logistic regression modelling with generalised estimating equations providing correct confidence intervals for odds ratios.

Analyses were computed with the SAS program package (version 6.12, Cary, NC, USA).

5. RESULTS

5.1 Physical activity

5.1.1 Distribution of physical activity (I)

In categories of physical activity 4-5 times a week or daily, the proportion of boys was higher than girls, but there was a higher proportion of girls engaged in moderate physical activity. Among 16-year-old boys, 13.4% participated in physical activity less than once a month, 9.5% 1-2 times a month, 17.7% once a week, 25.9% 2-3 times a week, 16.1% 4-5 times a week, and 17.4% daily. Among girls aged 16, 11.1% participated in physical activity less than once a month, 10.3% 1-2 times a month, 21.5% once a week, 31.4% 2-3 times a week, 12.7% 4-5 times a week, and 13.0% daily (Figure 2). For both sexes, the proportions of subjects in these categories differed by less than two percentage points at 17 and 18 years when considered as group-based data. The proportions at different physical activity levels are seen in Figure 2.

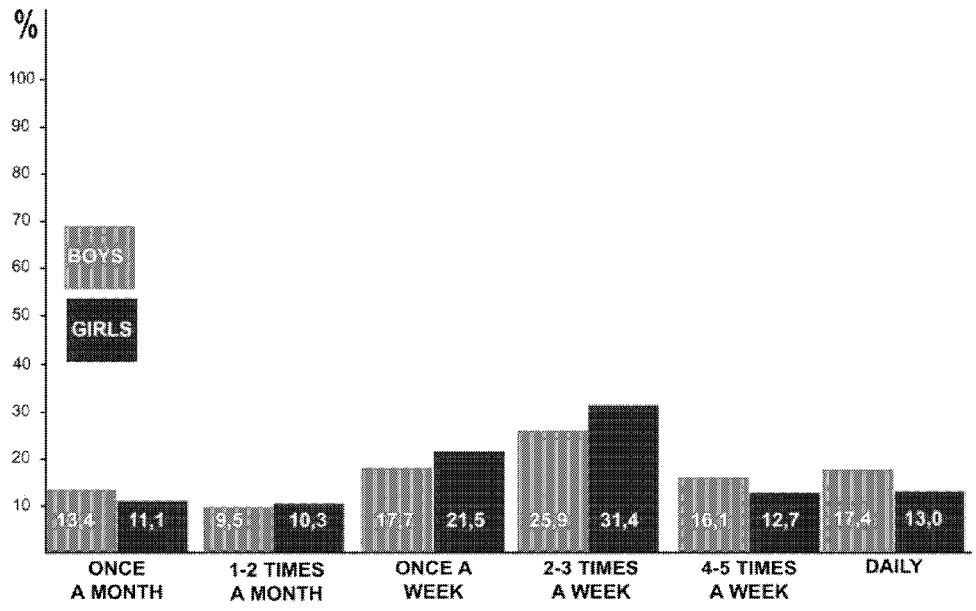


Figure 2. Frequency of physical activity at the age of 16.

5.1.2 Stability and changes of physical activity (I)

Of the boys who participated in physical activity daily at the age of 16, 46.7% did so also at the age of 18, while only 1.7% were physically inactive (less than once a month) at that age. Among inactive boys at the age of 16, 44.4% were inactive at the age of 18 compared with 2.1% who were now physically active. Of the girls who participated in daily physical activity at the age of 16, 46.3% also did so at the age of 18, and only 2.8% were physically inactive at that age. Among inactive girls, 34.2% continued to be inactive, compared with 7.1% who were physically active at age 18. Thus, changes in physical activity were mostly between neighbouring categories, and changes from one extreme to another were quite rare (Figure 3).

When the data was analysed as individuals with repeated measurements, 20.4% of boys and 13.0% of girls were persistent exercisers (had remained in the same highest categories of exercise frequency over the three measurement occasions), and 6.5% of boys and 5.3% of girls were persistently inactive (in the same lowest categories of exercise frequency over the three measurement occasions).

Among boys who considered their fitness to be very good at the age of 16, 43.6% were persistent exercisers and 1.6% persistently inactive, while the corresponding figures for girls were 39.7% and 1.6%. The intensity of physical activity at 16 years also correlated with persistent exercising; of boys who breathed and sweated heavily during exercise, 42.8% were persistent exercisers and 1.3% persistently inactive, while the corresponding figures for girls were 31.5% and 3.9%.

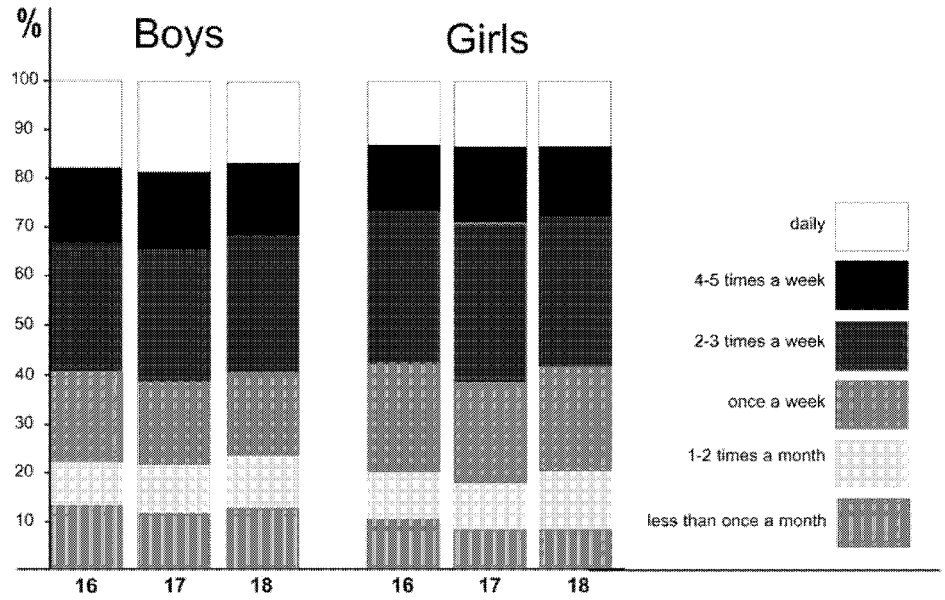


Figure 3. Frequency of physical activity at the ages of 16, 17 and 18 according to cross-sectional study.

5.1.3 Correlations with other measures of sports (III)

We next explored the relationship of persistent exercise with other measures of physical activity and sports activity. Nearly all the adolescents (96.1%) participated in some leisure-time physical activity, and reported at the age of 17 in what sports they participated. For example, it can be seen in Table 4 that 11.1% of boys and 13.3% of girls engaged in cross-country skiing, and 41.5% and 24.8% of them, respectively, were persistent exercisers. The sports with the highest proportions of persistent exercisers were quite similar in both sexes. Among boys these were basketball, tennis, gym-training, aerobics (only 10 cases), cross-country skiing, and jogging, while among girls cross-country skiing, gym-training, football, baseball and basketball were the main sports.

Table 4. Participation (number (N) and proportion (%)) in different types of sports at the age of 17 and proportion (%) of persistent exercisers among boys and girls participating in each type of sport.

		Boys			**Girls**		
The type of sport	Sports group	Number of all boys (N)	Proportion of all boys (%)	Persistent exercisers (%)	Number of all girls (N)	Proportion of all girls (%)	Persistent exercisers (%)
Biking	aerobic	506	35.0	17.3	881	53.4	11.1
Jogging	aerobic	421	29.2	33.7	977	59.2	13.7
Swimming	aerobic	213	14.8	16.0	402	24.4	10.9
Cross-country skiing	aerobic	161	11.1	41.5	220	13.3	24.8
Slalom	mixed	298	20.6	15.6	409	24.4	12.9
Aerobic dance	mixed	10	0.7	70.0	360	21.8	12.3
Gymnastics	mixed	49	3.4	16.3	287	17.4	15.4
Tennis	mixed	173	12.0	32.9	117	7.1	20.7
Football	mixed	284	19.7	27.3	69	4.2	27.9
Volleyball	mixed	179	12.4	21.4	130	7.9	20.8
Badminton	mixed	245	17.0	20.7	194	11.8	11.9
Finnish baseball	mixed	124	8.6	23.0	194	7.5	24.8
Basketball	mixed	141	9.8	32.6	79	4.8	28.6
Rinkball	mixed	160	11.1	27.4	17	1.0	25.0
Ice-hockey	mixed	305	21.1	26.7	29	1.8	25.0
Skating	mixed	143	9.9	20.6	181	11.0	15.3
Gym-training	power	475	32.9	31.1	283	17.2	26.6
Weight-lifting	power	199	13.8	22.0	40	2.4	7.5
Other types of sports+		443	30.7	24.6	461	27.9	16.4

+ The most common other sports were floorball and table tennis among boys and horseback riding, dancing and walking among girls.

We formed eight groups covering all the possibilities of participating in different groupings of sport types. For this analysis, we also considered all the open-ended answers not included in the 19 given alternatives, and assigned those persons too to the three possible groups (aerobic, power, others). Those participating only in sports in the aerobic group had the lowest proportion of persistent exercisers, while those reporting participation in sports from all three groups were more often persistent exercisers (Table 5). Power exercise also seemed to be associated with persistent physical activity.

Table 5. Number (n) and proportion (%) of persistent exercisers among boys and girls by combinations of groupings of sports (aerobic, power, others) at the age of 17.

			Boys		Girls	
Aerobic	**Others**	**Power**	**Number**	**Proportion (%)**	**Number**	**Proportion (%)**
-	-	-	0	0	0	0
+	-	-	5	4.8	11	4.5
+	+	-	5	9.1	3	7.7
-	+	-	10	20.0	0	0
-	-	+	40	15.6	23	11.9
+	-	+	63	17.6	72	9.1
-	+	+	33	22.9	8	32.0
+	+	+	99	37.1	62	27.6

- : no participation in a sport classified in that group
+: participation in a sport classified in that group

An interesting finding was that among boys who participated in ball games, 23.1% were persistent exercisers, while among boys not participating in ball games the figure was 12.6%. Among girls who participated in ball games, 25.0% were persistent exercisers, and among girls not participating in ball games the figure was 8.6%.

Overall, 35.2% of boys reported that they participated in organised sport compared to 20.5% of girls. Among persistent exercisers, 80.4% of boys and 61.2% of girls participated in organised sports groups of some kind.

5.2 Correlations of health-related behaviours, social relationships and health status with physical activity

5.2.1 Associations between health-related behaviours and physical activity (I, IV)

Smoking was strongly associated with decreased physical activity level at the age of 16 (girls and boys, $p < 0.001$). The frequency of regular smokers in the very active class among girls was 13.3%, and in the inactive class 55.6%. Among boys, 11.8% of the very active class compared to 35.6% of the inactive class smoked regularly (Figure 4). Also, at the three-year follow-up non-smoking was significally associated with persistent exercisers and smoking with persistent inactivity among both boys and girls (Table 6).

The *use of alcohol* differed significantly across physical activity groups at the age of 16 (girls $p< 0.001$ and boys $p = 0.056$) (Figure 5). The frequency of heavy users increased systematically as the physical activity level decreased, and the frequency of non-users decreased when the physical activity level increased. Among girls, 9.8% of the very active and 29.7% of the physically inactive were heavy users. Among boys, 14.0% of the very active and 26.1% of the inactive belonged to the heavy user class. When smoking habits were taken into account in a three-factor log linear analysis (smoking, alcohol use and physical activity), alcohol was no longer significantly associated with physical activity. The association between alcohol use and physical activity was thus accounted for by the association of smoking and alcohol use, and of smoking with physical activity. In the three-year follow-up, alcohol use was no longer associated with persistent exercise or persistent inactivity (Table 6).

Figure 4: Smoking in different physical activity groups among boys and girls

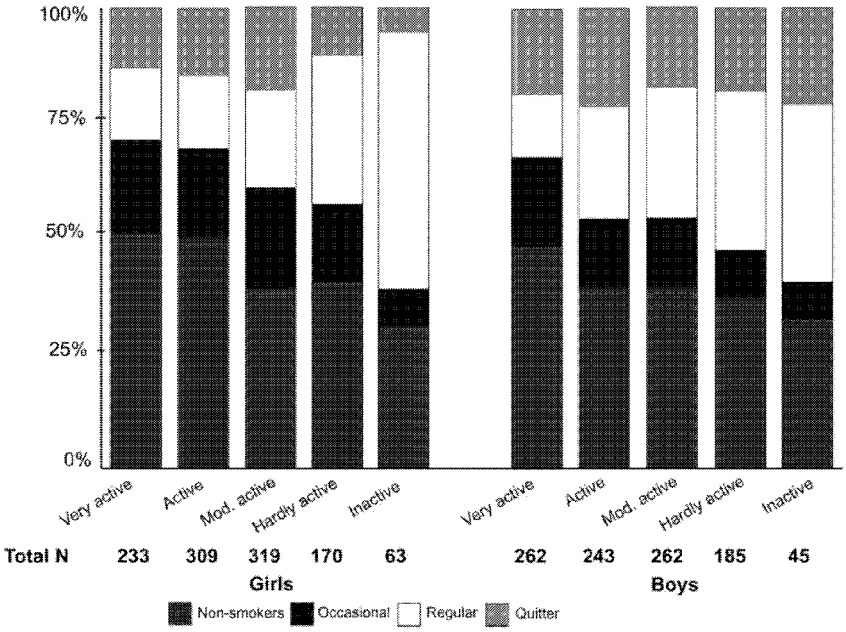
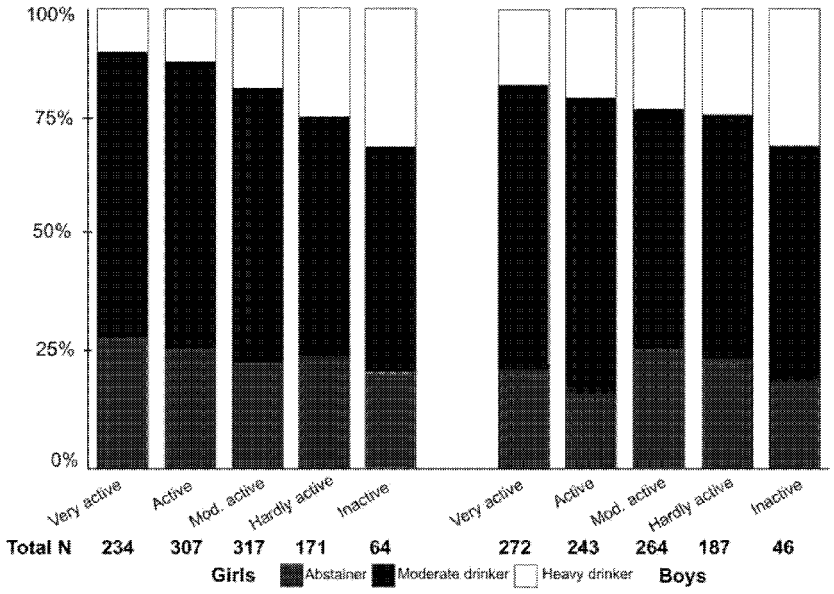


Figure 5: Alcohol use in different physical activity groups among boys and girls



There were no significant differences in either sex in the *body mass index* by physical activity level at the age of 16, or by persistent physical activity.

The u*se of spreads* on bread differed significantly across physical activity classes at the age of 16 (girls p = 0.001 and boys p = 0.037). Among girls, the proportion of those who did not use any spread increased when the physical activity level increased; in the very active class 15.4 % did not use any spread compared to 1.6 % in the inactive class. Among boys the corresponding proportions were 5.2 % in the very active class and zero in the inactive class (Figure 6). In the three-year follow-up, too, non-use of spreads on bread was associated with persistent exercising among girls, but not among boys. Also, regular breakfast eating was associated with persistent exercising among boys and girls, but irregular breakfast eating only among persistently inactive boys (Table 6).

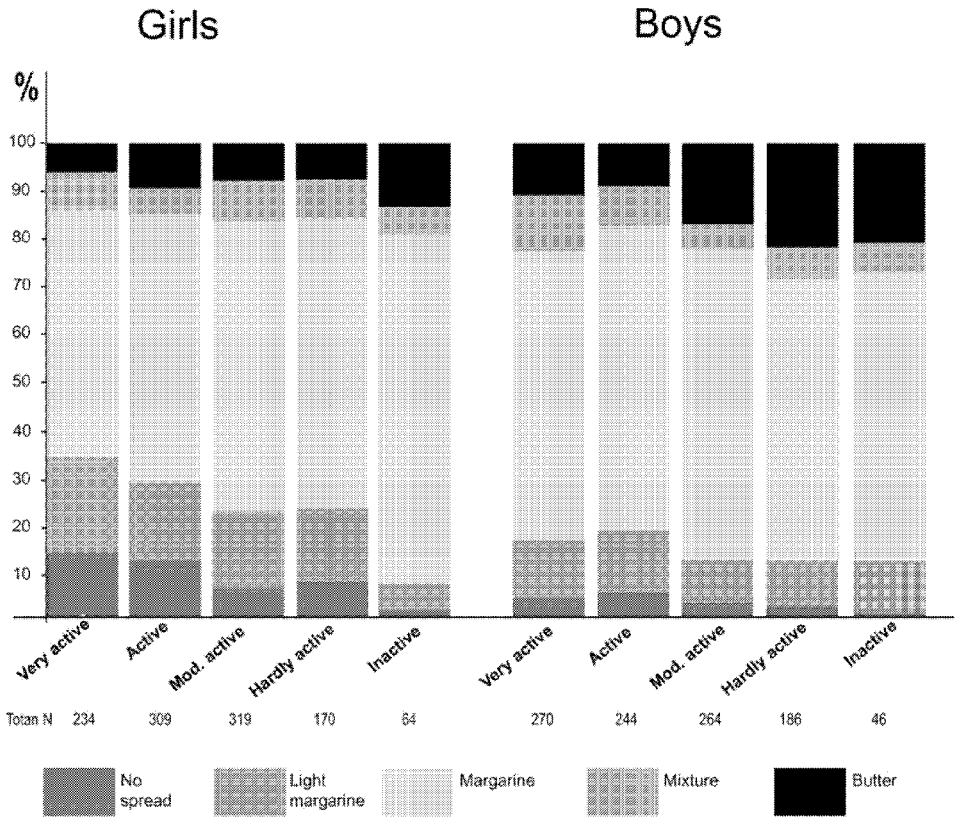


Figure 6. Use of spread on the bread in different physical activity groups among girls and boys.

5.2.2 Associations between social relationships and physical activity (I, IV)

At the age of 16 there were no significant differences between *working and going to school* in different physical activity groups among boys, but a significant difference ($p < 0.005$) was observed among girls. Moreover, a significant difference ($p < 0.001$ for girls and boys) was found in the type of school attended. Those who were physically very active or active mainly attended comprehensive school or high school. When comparing high school to vocational school, 46.8 % of the very active girls attended high school and 7.3 % vocational school. Of the inactive girls, 22.6% attended high school and 17.7 % vocational school. Among the very active boys 36.5 % attended high school and 15.4 % vocational school. Furthermore, 20.0 % of the inactive boys attended high school, but 44.4 % attended vocational school. These statistics show that the frequency of students in vocational schools increased when the physical activity level decreased, particularly among boys. In the final logistic regression, attending high school was significantly associated with persistent exercising, and attending vocational school with persistent inactivity among boys and girls; for example those in vocational school had ORs of 1.65 (1.04 to 2.62) (boys) and 1.83 (1.10 to 3.04) (girls) compared to high school students (Table 6).

In a three-factor log linear analysis (physical activity, smoking, school type), both smoking and school type remained significantly associated with physical activity among girls and boys at the age of 16. No significant difference was found in the *leisure time company* in different physical activity groups, nor between boys and girls. In general, boys (41 %) seemed to spend more time in large groups than girls (31%).

In the three-year follow-up, mother's socioeconomic status was associated with persistently active boys, and father's with persistently inactive boys, but there were no associations among girls. The final logistic regression results are shown in Table 6.

Table 6. Multivariable logistic regression analyses of health-related behaviours, social relationships and health status variables in relation to physical activity patterns among boys and girls at 16, 17 and 18.5 years in the FinnTwin16 study. Odds ratios and 95% confidence intervals (95% CI) for persistent activity.

		PERSISTENT EXERCISERS BOYS			
Variables	**N**	**n (%)**	**OR**	**(95% CI)**	**P**
Smoking					
Regular smoker	472	21 (4.5%)	0.20	(0.11 to 0.36)	*
Occasional smoker†	790	178 (22.5%)	0.87	(0.66 to 1.15)	
Non smoker	936	234 (25%)	1.00		
Alcohol					
Heavy users	397	49 (12.3%)	1.28	(0.95 to 1.72)	
Users	1285	283 (22.0%)	0.92	(0.55 to 1.53)	
Non users	548	113 (20.6%)	1.00		
Breakfast eating					
Once a week	274	13 (4.7%)	0.39	(0.23 to 0.67)	*
3-4 times a week	283	25 (8.8%)	0.76	(0.50 to 1.14)	
Every morning	1670	213 (12.6%)	1.00		
School type					
Vocational school	885	107 (12.1%)	0.46	(0.34 to 0.64)	*
Other alternatives‡	194	16 (8.3%)	0.40	(0.22 to 0.75)	*
High School	1139	318 (27.9%)	1.00		
School grade					
Worse than average	62	1 (1.6%)	0.38	(0.09 to 1.53)	
Other alternatives§	1808	353 (20%)	1.26	(0.90 to 1.76)	
Better than average	323	88 (27.2%)	1.00		
Mother's socio-economic status					
Lower-level employee	1015	207 (20.4%)	0.86	(0.59 to 1.23)	
Workers	437	86 (19.7%)	1.18	(0.74 to 1.88)	
Self-employed	98	19 (19.4%)	0.25	(0.08 to 0.77)	*
Farmers	160	27 (16.9%)	0.75	(0.40 to 1.40)	
Upper-level employee	308	75 (24.3%)	1.00		
Own perception of current health					
Poor§§§	20	1 (5%)	0.27	(0.04 to 1.51)	
Other alternatives¶	1222	159 (13%)	0.47	(0.37 to 0.61)	*
Very good	1011	290 (28.7%)	1.00		
BMI					
26>	82	11 (13.4%)	2.71	(1.13 to 6.46)	
19-25	1813	335 (18.5%)	2.40	(1.50 to 3.85)	
<18	244	27 (11.1%)	1.00		

		PERSISTENT EXERCISERS GIRLS			
Variables	**N**	**n (%)**	**OR**	**(95% CI)**	**P**
Use of dietary fats					
Light, mixed, butter	776	97 (12.5%)	0.39	(0.27 to 0.55)	*
Margarine	1553	158 (10.2%)	0.45	(0.25 to 0.81)	*
Nothing	307	81 (26.4%)	1.00		
Smoking					
Regular smoker	522	23 (4.4%)	0.52	(0.30 to 0.91)	*
Occasional smoker†	988	115 (11.6%)	0.77	(0.56 to 1.07)	
Non smoker	1121	198 (17.7%)	1.00		
Alcohol					
Heavy users	409	25 (6.1%)	0.84	(0.61 to 1.16)	
Users	1680	213 (12.7%)	0.44	(0.22 to 0.90)	
Non users	552	99 (17.9%)	1.00		
Breakfast eating					
Once a week	405	36 (8.9%)	0.62	(0.40 to 0.96)	*
3-4 times a week	419	38 (9.1%)	0.68	(0.45 to 1.02)	
Every morning	1820	269 (14.8%)	1.00		
School type					
Vocational school	616	38 (6.2%)	0.46	(0.29 to 0.71)	*
Other alternatives‡	271	13 (4.8%)	0.33	(0.15 to 0.72)	*
High school	1744	284 (16.3%)	1.00		
School grade					
Worse than average	37	2 (5.4%)	1.76	(0.31 to 9.94)	
Other alternatives§	1957	194 (10%)	0.79	(0.58 to 1.06)	
Better than average	601	137 (22.8%)	1.00		
Mother's socio-economic status					
Lower-level employee	1165	155 (13.3%)	0.86	(0.58 to 1.25)	
Workers§§	533	53 (9.9%)	0.77	(0.48 to 1.24)	
Self-employed	126	14 (11.1%)	0.81	(0.38 to 1.69)	
Farmers	155	18 (11.6%)	0.69	(0.33 to 1.44)	
Upper-level employee	360	66 (18.3%)	1.00		
Own perception of current health					
Poor§§§	33	1 (2.9%)	0.37	(0.16 to 0.83)	*
Other alternatives¶	1676	152 (9.1%)	0.56	(0.42 to 0.73)	*
Very good	934	183 (19.6%)	1.00		
BMI			**NIC**		
26>	106				
19-25	2092				
<18	371				

* $p<0.05$

† Includes also quitters.

‡ Other alternatives are comprehensive school, university, higher vocational school, other courses.

§ Other alternatives are little bit better, average, little bit worse.

§§ Includes unprofessional workers, unemployed and retired.

§§§ Two lowest classes, very poor and poor, are combined.

¶ Other alternatives are rather good and average.

NIC Not included in the final analyses.

5.2.3 Associations between health status and physical activity (I,IV)

Both boys' and girls' *own perception of their health* was associated with physical activity at the age of 16 ($p < 0.001$), with the physically active reporting higher perceived health status. In the three-year follow-up in the final logistic regression, good perceived current health was significally associated with persistent exercise and poor perceived current health with persistent inactivity among boys and girls.

Eleven percent of the girls and 10 % of the boys reported a *long-term illness* that hindered daily activities. The five most common reasons were allergies, asthma, errors of refraction, diabetes mellitus and migraine.

At the age of 16, there was a significant association among all girls between mean number of *psychosomatic symptoms* and physical activity group ($p <0.001$, ANOVA). The number of symptoms was highest in the inactive group and lowest in the very active group ($p < 0.001$, t-test). The association, however, was not statistically significant among boys ($p = 0.07$, ANOVA) (Figure 7). When smoking and school type were taken into account in a linear regression model, the association between the psychosomatic symptom score and physical activity remained statistically significant for all female subjects, with the adjusted mean of the symptoms being highest among the inactive. When subjects reporting a long-term illness were excluded, the association between symptoms and physical activity among girls remained significant, while no association was seen for boys. In the three-year follow-up, there was no association between psychosomatic symptoms and persistent exercise or inactivity.

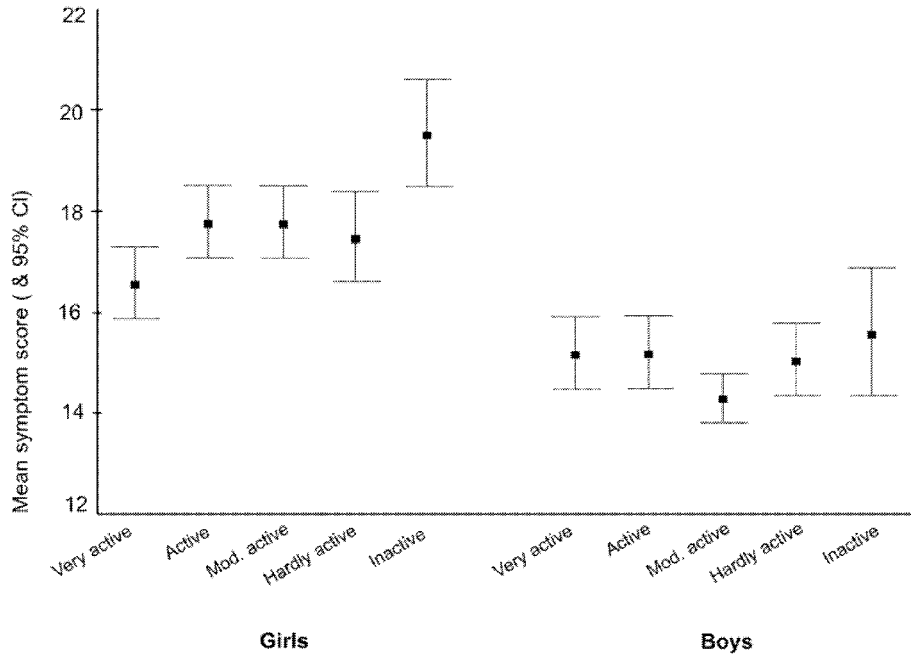


Figure 7. Psychosomatic symptoms (means and 95% cl) in different physical activity groups among boys and girls (initial analyses).

5.3 Familial aggregation of physical activity (II)

The parental and grandparental correlations of physical activity classes are seen in Figure 8. For each family relationship the number of such relative pairs is given together with the estimated correlation of physical activity level in the entire data.

Intragenerational physical activity patterns were associated with each other, especially among adolescents and grandparents. Among adolescents the strongest correlation was between monozygotic boys (0.72) and girls (0.64) and the weakest between twins from pairs of the opposite sex (0.22). Correlations between dizygotic girl pairs (0.41) and dizygotic boy pairs (0.45) were similar.

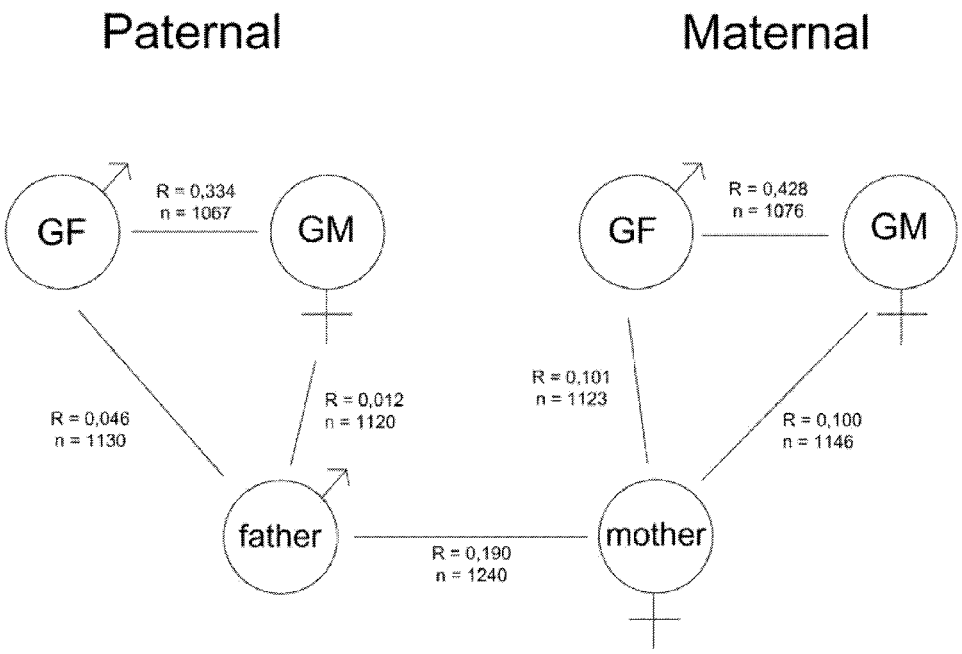


Figure 8. Parental and grandparental correlations of physical acitivity classes. All correlations are significant (p<0,01), except between father and paternal grandparents.

Among all girl pairs, 69.6% of very active girls had a very active sister and 45.5% of inactive girls had an inactive sister. Among all boys, 58.7% of very active boys had a very active brother and 39.4% of inactive boys had an inactive brother.

The correlation between parents themselves was 0.19. Among very active mothers 28.6% had a very active husband and among inactive mothers 32.6% had an inactive husband. Among those couples in which both were farmers, 20.0% of active mothers had an active husband, and of those in which neither were farmers, 28.2% of active mothers had an active husband.

Grandparents' own physical activity patterns, as reported by their adult children, showed that 55.5% of physically active maternal grandmothers had an active husband and 17.9% an inactive husband. In contrast, only 10.8% of inactive maternal grandmothers had an active husband and 64.2% of inactive grandmother had an inactive

husband (correlation 0.43). Among active paternal grandmothers 43.7% had an active husband and 25.3% an inactive husband. Among inactive paternal grandmothers 11.5% had an active husband and 66.3% an inactive husband (correlation 0.33).

Intergenerational physical activity patterns seemed not to be associated, as these correlations were quite low in the entire family data. The correlations between father and adolescent (0.08) and mother and adolescent (0.09) were similar. The strongest correlation was between father and boy (0.10), and weakest between father and girl (0.05). Grandparental physical activity was not associated with the parental or adolescent physical activity patterns. Because of the lack of associations across compared to within generations, we examined how persons at the extremes of the distributions of physical activity were associated. Table 7 shows cross-tabulation of the extreme classes (very active and inactive) of parents and children.

There was a significant difference between very active and inactive mothers and their daughters' physical activity ($p<0.001$), but not between extreme classes of mothers and their sons ($p=0.142$). No statistically significant association was found between extreme classes of fathers and their daughters ($p=0.898$) or sons ($p=0.096$).

Table 7. Physical activity levels in adolescents according to whether parents were very active or inactive.

Parent	**Adolescent**	**Parental physical activity**	**Adolescent physical activity**				
			very active %/n	active %/n	modera-tely active %/n	hardly active %/n	inactive %/n
Mother	girl	very active	33.3%	27.6%	27.6%	11.4%	0%
			41	34	34	14	0
		inactive	15.4%	36.2%	27.5%	14.1%	6.7%
			23	54	41	21	10
Mother	boy	very active	25.5%	27.5%	27.5%	16.7%	3.3%
			30	33	33	20	4
		inactive	23.5%	17.5%	28.2%	22.3%	8.1%
			35	26	42	34	12
Father	girl	very active	25.2%	30.3%	22.7%	16.9%	5.0%
			30	36	27	20	6
		inactive	25.2%	31.3%	23.8%	12.9%	6.8%
			37	46	35	19	10
Father	boy	very active	37.2%	24.8%	22.3%	10.7%	5.0%
			45	30	27	13	6
		inactive	22.3%	24.6%	30.0%	16.2%	6.9%
			29	32	39	21	9

6. DISCUSSION

6.1 Main results

Based on these findings, persistently active adolescents smoke less and have better health and nutritional habits and better self-estimated health than inactive adolescents. They attend high schools more often than vocational schools, where they are likely to be superior rather than poor achievers. Participation in organised sport, in a variety of sports, in power sports, and in ball games is all associated with persistent physical activity. Except for the association between active mothers and daughters, parents' and grandparents' physical activity is generally not associated with adolescent physical activity. Co-twins' physical activity is, however, associated.

6.1.1 Stability and changes of physical activity

In this study, the proportions of very active adolescents were similar at each age. However, the longitudinal three-year follow-up showed substantial changes over time among individuals from one physical activity group to another. About a fifth of boys and every tenth girl were persistent exercisers over a 30-month period in late adolescence (III). According to most studies, physical activity decreased from childhood to adolescence (Sallis 1993, Hämäläinen et al. 2000, Kimm et al. 2000, van Mechelen et al. 2000).

Some longitudinal studies have found moderate to low tracking correlations, and others moderate to high. In a Finnish six-year follow-up study (baseline ages 12, 15 and 18 years) all tracking correlations over a six-year period of physical activity were significant, varying from 0.5 to 0.8 among boys and 0.4 to 0.61 among girls (Raitakari et al. 1994). Tracking correlations are generally moderate or low (Kelder et al. 1994, Anderssen et al. 1996, Pate et al. 1996, Telama et al. 1996, 1997), but according to Janz et al. (2000) tracking of physical activity was moderate to high. In the Finnish study mentioned above, physical inactivity showed better tracking than physical activity, and subjects who were constantly inactive had a less beneficial coronary risk profile (Raitakari et al. 1994). Similar results were found in the Muscatine study, where sedentary behaviour tracked better in boys and vigorous behaviour in girls (Janz et al. 2000).

Those who are persistent exercisers during adolescence may be more likely to continue a physically active life in adulthood, where the health benefits will be seen. This research project shows that healthier lifestyles are associated with higher physical activity, and therefore the persistently inactive group is the biggest challenge in promoting health. However, this does not mean that inactive adolescents are doomed to be inactive adults.

6.1.2 Correlations with other measures of sport

In this study, stability of leisure-time physical activity was highest among those who participated in several different types of sport, and those who took part in organised sports were more often persistent exercisers and persistently fit than those who did not. Stability was high among those participating in ball games or power types of sport (III).

An association of organised sports with high physical activity stability has been reported earlier. Participation in competition sports (Telama et al. 1997) and membership of a sports club (Barnekow-Bergkvist et al. 1998) are predictors of later physical activity. According to Telama et al. (1996), the tracking of participation in organised sport is moderately high among adolescents compared with the dropout rate from sports in general. This may be because the stability of non-organised physical activity appears to be lower than the stability of organised sports. The explanation for this could be that it is more difficult to estimate and remember non-organised activities (Telama et al. 1996). Also, the role of organised sports might change during adolescence. According to a 15-year follow-up, over the course of time organised sports activities became a relatively more important contributor to weekly habitual physical activity (HPA) and energy expenditure (van Mechelen et al. 2000).

Based on this study, among boys the proportion of persistent exercisers was highest in those who participated in cross-country skiing, jogging and bodybuilding, and among girls in those who participated in ball games. Whether these historical trends hold as new sports increase in popularity and spread among adolescents remains to be seen; recommending one particular sport over another should be done very cautiously. The association of power type sports and ball games with persistent physical activity is also interesting. Is power type exercise a supplementary training to some other sports, or are there some other reasons, for example friends at the gym? Power types of exercise can be forms of both personal and social training. Is participation in ball games equivalent to organised sports? These issues need further investigation.

6.1.3 Association with health-related behaviours, social relationships and health status

In this study, associations of physical activity with health-related behaviours, social relationships and health status were first measured in a cross-sectional study (I) at the age of 16. Physical activity measures were then repeated, and so-called persistent activity and inactivity determined over a three-year period (16, 17 and 18.5 years) and then compared to the health-related behaviours, social relationships and health status at the age of 16 (IV).

Smoking

Smoking was strongly negatively associated with physical activity and persistent physical activity at the age of 16 in both boys and girls (IV). This accords with other studies finding that more physical activity is related to less smoking in both sexes (Escobedo et al. 1993, Raitakari et al. 1994, Donato et al. 1997, Page et al. 1998, Yang et al. 1999). A few studies have produced opposite results. Lewis et al. (2001) found no association between smoking and physical activity among adolescents aged 10 to 15 years. A Danish study of 16-19-year-old school children found no differences in fitness levels between non-smokers and those who smoked more than 20 cigarettes per week (Andersen et al. 1989).

In the Finnish cohort study (ALHS), students involved in interscholastic sports were less likely to be regular or heavy smokers than others who had not participated (Rimpelä and Rimpelä 1993). A negative correlation between physical activity and smoking has usually been reported to be stronger among boys than girls, but our study showed no gender difference. Among adolescent girls, smoking is considered a good way to lose weight. Dieting among girls may also exacerbate the risk of initiating smoking (Austin and Gortmaker 2001). Therefore physical activity should be recommended more as a healthy way to control weight.

Alcohol use and abuse

According to our study, the frequency of heavy drinkers increased when the physical activity level decreased. When smoking habits were taken into account, the difference in alcohol use between physical activity groups was not significant (I). There was no association between alcohol consumption and persistent physical activity (IV).

The results of the very few studies of physical activity level and alcohol use among adolescents differ. According to a Finnish study of 11-16-year-olds, those who used alcohol spent less time in physical activities than non-users. Girls in the drinking group were less active than boys (Honkala 1984). Page et al. (1998) studied a nationally representative sample of 12 272 US high school students and found no association between alcohol consumption and participation in team sports. An association of alcohol use with reduced participation in conventional leisure-time activities in early adolescence was found in another US study of 1 092 predominantly low socio-economic status rural school children aged 11-18 (Terre et al. 1990). Opposite results were reported among 878 college students: 80% exercised regularly and consumed alcohol (Blank et al. 1993).

The association of physical activity with alcohol use is not clear; it might be associated with developmental, pubertal, adolescent or environmental factors. Our study found the alcohol association was related to smoking. According to Felton et al. (1999), alcohol consumption was associated with parental or friends' drinking habits and increased with age. Regional aspects might also affect drinking habits due to socio-economic factors (Karvonen and Rimpelä 1998). Physical activity, especially in team sports, might simultaneously promote social bonding and increase the sense of belonging, thereby lowering risk-taking behaviour. Sports events are often sponsored by alcohol or beer companies, so it would also be interesting to study whether alcohol sponsorship has any effect on adolescent behaviour.

Nutritional habits

In the cross sectional study (I), dietary fat intake as measured by type of spread used on bread differed between physical activity classes, but an association was found in repeated measures only among girls (IV). Regular breakfast eating was associated with persistent physical activity among boys and girls (IV). According to a Finnish six-year follow-up study of diet among young men, physical activity was related to a lower consumption of saturated fatty acids and a higher polyunsaturated to saturated fatty acid ratio (Raitakari et al. 1994), which is consistent with the results of our analyses.

In this study, mean body mass index was not associated with physical activity among boys or girls. Less than 10% of the boys and girls had a body mass index (BMI) over 22, so there appears to be few overweight adolescent 16-year-olds. Kemper et al. (1999) found that high physical activity in both sexes was related to low body fat. Also, according to Klesges et al. (1984), obese children are less active than those of normal weight, but a Finnish study of school children found no significant association between

low physical activity and high BMI (Telama et al. 1983). Van Mechelen et al. (1999) found a positive longitudinal relationship between HDL-cholesterol and physical activity, but low tracking was found for physical activity and various dietary intake variables.

Social relationships

There were no significant differences in physical activity between those working or going to school, or according to the type of company in leisure time among girls and boys at the age of 16. School type, however, was associated with physical activity. The most active adolescents attended comprehensive or high schools, with the most inactive attending vocational schools (I). Superior school achievement was also associated with persistent physical activity (IV). Mother's socio-economic status was associated with persistent physical activity of boys and girls, and father's with persistent inactivity of boys (IV).

An association of low socio-economic status (SES) with low physical activity has been reported elsewhere. Low socio-economic status was associated with less physical activity in other studies (Lee and Cubbin 2002), but Gordon-Larsen et al. (2000) found in a representative US sample that maternal education was inversely associated with high inactivity of high school adolescents. Also, according to Kristjansdottir and Vilhjamsson (2001), upper class students were less sedentary and more physically active than working class students. In a Danish study, 370 children aged 6-18 were followed-up for 13 years: lower physical activity was associated with low education among young women, while father's activity level at work was associated with young men's physical activity. Men whose parents reported high physical activity at work were less often physically inactive during leisure time (Osler et al. 2001). According to Daley and Ryan (2000) no significant association was found between physical activity and academic performance among 13-16- year-old English adolescents. A Finnish study found that low parental socio-economic status was associated with smoking, low physical activity and obesity among boys (Leino et al. 1996).

Our study project found associations of school type and school achievement with physical activity. Comprehensive schooling ends at the age of 16, and adolescents then have to decide about their further education. At the same time adolescents are making many other decisions about their leisure-time hobbies, with whom they spend their leisure time, how they spend their pocket money, etc. Late adolescence can also be the time of life when decisions are made about physical activity. In this project we did not

study the social aspects of late adolescent decision-making. Social relationships encompass a broad area, of which this study covers only part.

Health status

The subjects' own perception of being healthy was associated with physical activity (I) and with persistent physical activity (IV). These findings are logical, especially since long-term illness among these 16-year-old boys and girls was uncommon. An association between high number of psychosomatic symptoms and physical inactivity was found among girls, but not boys. This accords with studies on adults, which have found that females report more psychosomatic symptoms. However, even though adult women seem to report symptoms more readily (Klesges et al. 1984), men tend to have more serious illnesses, e.g. coronary heart disease (Aromaa et al. 1989). In a Dutch longitudinal study (Amsterdam Growth and Health Study) adolescent physical activity was not associated with most of the indicators of adult cardiovascular health status (van Mechelen et al. 1999).

6.1.4 Familial aggregation of physical activity

Intragenerational physical activity patterns showed substantial correlations in all three generations of adolescents, parents and grandparents. The physical activity patterns of twins of the same sex, particularly monozygotic twins, were highly correlated. This suggests that physical activity patterns are influenced by a sib of the same sex, and also might have a genetic background. However, intergenerational physical activity patterns showed weak associations. Grandparents' physical activity was reported by parents (their children), and can be subjective. Also, the nature of work was more active in earlier decades. Leisure-time physical activity was not necessarily needed.

When the overall data set was analysed, the 16-year-old adolescents' physical activity patterns were not associated with either parents' or grandparents' physical activity patterns. When the extremes of physical activity patterns were considered, a significant association between mothers and daughters was seen. The corresponding association for fathers and sons was not as strong, but the results suggest that parents are more likely to affect the physical activity patterns of their same-sex children in adolescence, while opposite-sex offspring are less influenced. Also, very active or quite inactive parents appear to affect their children more than moderately active parents. However, it cannot be totally excluded that in families with adolescents aged 16 years, adolescent physical

activity patterns influence parental habits. For example, a physically very active youth may activate a previously less active parent into more physical activity.

Among other studies, Stucky-Ropp and DiLorenzo (1993) found certain variables to predict the level of physical activity among boys and girls in the 5th and 6th grades. Support and modelling from friends and family were predictors among boys, but not girls. For girls only, physical activity appears to be more highly influenced by the number of exercise-related pieces of equipment at home, and parental modelling of exercise. Father's occupation is significantly related to the frequency of exercise (Gottlieb and Chen 1985).

Although our study population consisted of twins, we generally discarded their twinship and did not study genetic associations. Genetic association was reported by Beunen and Thomis (1999), who found that if one of the parents or co-twins is active in sports, it is more likely that the child or co-twin is also similarly active. According to another twin study, monozygotic twinpair correlations of physical activity are reportedly higher than dizygotic, suggesting that genes play a role in physical activity patterns (Lauderdale et al. 1997).

This study did not include genetic aspects nor take causality into consideration. Longitudinal studies of children through adolescence and of their parents would be necessary to examine the pattern of causation for these observed associations.

6.1.5 Gender differences

Physical activity

In our study boys were more active than girls, their correlations over time were higher, and our measure of stability, i.e. persistent physical activity, was also higher among boys. Many studies, but not all, agree with this observation of a gender difference apparently favouring boys. Sallis (1993) reviewed nine studies that used standardised self-reports or objective measures of physical activity. According to the findings, a constant decline in physical activity was seen over the school age years, among boys by 2.7% and among girls by 7.4%. The Muscatine study showed in a five-year follow-up that sedentary behaviour tracked better in boys, whereas vigorous activity tended to track better in girls (Janz et al. 2000). The same trends were seen in the Adolescent Health and Lifestyle Survey, where the physical activity of 12-, 14-, 16-, and 18-year-old Finns was studied in nationally representative biannual postal surveys in 1977-1999. According to Hämäläinen et al. (2000) this survey showed that in 1999 65% of boys and 55% of girls

participated in physical activity four times a week or more at the age of 12. The proportion of the very active declined with age; among boys from 26% to 12% and among girls from 13% to 5% between 12 and 18 years (Hämäläinen et al. 2000). Those data are not longitudinal, however, but from repeated cross-sectional surveys, and we do not know what has happened on the individual level. Opposite results were found in the Amsterdam Longitudinal Growth and Health study, where the decrease was greater among boys (42%) than girls (17%) between the ages of 13 and 27 in a 15-year follow-up (van Mechelen et al. 2000).

Furthermore, the gender differences are pronounced in most countries. For example, the proportion of girls exercising actively is approximately half that of boys among 15-year-olds in Greenland, Lithuania and Greece (Hickman et al. 2000). Also, according to Portuguese study, girls belonged more often to inactive or low active groups than boys (Mota and Esculcas 2002). The issue of gender differences is also relevant when we consider physical activity tracking from adolescence into adulthood. According to Barnekow-Bergkvist et al. (1998) more men than women participated in sports activities (70% vs.41%) at the age of 16, but at 34 years there was no significant difference.

Health-related behaviours and other determinants

The findings were generally similar for boys and girls. Poor health was a strong predictor of persistent exercise in both genders, even after excluding subjects with diseases hindering physical ability. The patterns of association between physical activity and health-related behaviours, social relationships and health status seem to be very similar among girls and boys. Smoking was strongly associated with a low level of physical activity in both sexes. The association of use of alcohol with physical activity appeared to be accounted for by the association of both with smoking in the multivariate model. The only statistically significant gender difference was for the association of psychosomatic symptoms with physical activity, but this could not be repeated in the smaller, confirmatory dataset. Girls in low physical activity groups reported more psychosomatic symptoms. The type of school was also associated with physical activity. The most active boys and girls went to comprehensive or high school, while the physically inactive group was more likely to be found in vocational schools among boys. According to Osler et al. (2001), young women were significantly less physically active during leisure time if poorly educated and smokers.

Girls seem to be a key target group for the prevention of both smoking and sedentary life styles. Gender differences are pronounced in most studies, but for unclear reasons.

One reason might be that boys are more likely to participate in ballgames and organised sports. The situation might be different today, since new types of physical activity, e.g. aerobics, have become very popular among girls, at least in Finland. Puberty, nutritional habits and environmental factors such as improved facilities might all have influence, and should be studied further.

6.2 Methodological issues

A major strength of this study is that the responses of the questionnaire were completed three times, at the ages of 16, 17 and 18, covering a three-year period. The number of subjects and the response rates were high. A relative weakness of the study is that it is informative only of late adolescence.

Our study had a high response rate and we have earlier shown a high one-month test-retest reliability of our questionnaire items. The questionnaire-reported physical activity correlated moderately with the laboratory tests, interview and VO_2 max measurement. There are contrary opinions about the use of questionnaires for such a purpose. According to Sirard and Pate (2001), subjective techniques such as surveys, self-report questionnaires, interviews, proxy-reports and diaries are the least reliable methods. However, subjective methods are often the only cost-efficient way to study large samples in epidemiological studies.

Previous studies have also shown that a single question concerning leisure-time physical activity correlates with maximal oxygen uptake and can be used to provide useful information about fitness and physical activity (Schechtman et al. 1991, Siconolfi et al. 1985). Crocker et al. (1997) Considered that a physical activity questionnaire for older children is a cost-efficient method of assessing general levels of children's physical activity during their school years. Valid and appropriate measurement of physical activity is, however, a challenging task because it can vary considerably both within and among individuals and populations (Kriska and Caspersen 1997), and because there are several health-related dimensions of physical activity, such as caloric expenditure, aerobic intensity, weight bearing, flexibility and strength (Caspersen 1989).

In this study concentrating on adolescent physical activity patterns we decided to use a self-report questionnaire as the measurement tool; the number of subjects was so large that this method was the most cost-efficient way to study physical activity. The same method has been used in another Finnish study, the biannual Adolescent Health and Lifestyle Survey (AHLS) of adolescent health and lifestyle among 12-, 14-, 16- and 18-

year-olds. In the AHLS two variables are used to measure physical activity: frequency - by asking the amount of time spent in physical activity, and intensity - by the level of sweating and breathlessness. In our study we formed physical activity categories by combining these two questions.

We repeated the same questions three times over a three-year period to examine changes in physical activity patterns. However, the response rate among those answering the first questionnaire was higher than among those who answered all three. We did not study whether those answering all three were more active in general, and the drop-out effect could not be estimated in this work.

Although our study population consisted of twins, we discarded their twinship in the analyses and considered them solely as individual adolescents drawn from the population. This procedure has been used in earlier analyses of individuals of the twin cohort (Kaprio et al 1990, Verkasalo et al. 1997), and inferences from epidemiological analyses of twins considered as individuals are comparable with those based on singletons. We have shown that physical activity patterns in twin individuals and singletons are similar (II). There is little reason to assume that the determinants of change in physical activity patterns would be different in large numbers of twins or singletons.

The material of this study is unique, as physical activity patterns of three generations have not been reported in earlier studies. Information on grandparental leisure time physical activity was based on parents' reports, which might raise the question of its reliability. The lack of association of three generations of physical activity might be due to the measures we used, which differed between the generations. The parental and adolescent measures of physical activity reflected current activity patterns, which may be highly age- or cohort-specific. On the other hand, the assessment of grandparents was based more on a global lifetime perspective. Hence, these may not be fully comparable if physical activity patterns vary a great deal over time. We therefore based our analyses on computing relative activity levels within generations.

6.3 Sociocultural changes in Finland

Finnish society has undergone tremendous changes over recent decades. Farmers have become a minor socio-economic class and there has been huge migration of the population from the countryside to urban areas. The working week has become shorter; in 1945 the average working week was 47 hours and in 1966-70 40 hours

(Valtioneuvosto 1983). During the last 40 years working time has decreased by 12 hours/year and leisure-time has expanded. Leisure-time has also increased because of rising unemployment (Mäntylä et al. 1990), particularly since 1990. At the same time, work has become less physically demanding.

Due to the growing awareness of the health benefits of physical activity, leisure-time physical activity has gained higher priority as a means of keeping fit and preventing the possible negative consequences of physical inactivity.

Moreover, the opportunities for leisure-time physical activity have expanded from generation to generation. Today's adolescents have access to numerous alternative forms of exercise. At the end of the 1950s there was one physical activity facility for every 1200 citizens, of which two-thirds were outdoors, whereas in 1990 there was a sports facility for every 200 citizens (Heikkinen et al. 1992).

As these options have expanded, physical education classes at school have decreased. Today, the responsibility for physical activity falls more on the adolescent him/herself, or their family. Nevertheless, comprehensive schools need to recognise that there appear to be individual differences in the development of high-risk behaviours, and that scholastic aptitude seems to be an indicator of risk. Promoting physical activity among adolescents should lead to healthier overall lifestyles.

6.4 Physical activity recommendations

In Finland there is no national consensus recommendation for physical activity for adolescents, despite several studies of the subject. Guidelines for physical activity recommendations for adolescents are based on various consensus conferences and not necessarily on scientific evidence (Twisk 2001). According to publications in the United States and Britain, adolescents need moderate physical activity most days of the week and vigorous physical activity at least three times a week for 30 to 60 minutes per session (American College of Sports Medicine 1991). A recent consensus recommendation is that all children and adults should gradually build up to 30 minutes of moderate intensity activity on most, preferably all, days of the week, with more of an emphasis on physical activity than exercise (NIH Consensus Conference 1996). In addition, the Royal College of Physicians recognises that "the habit of taking regular recreational exercise is best started in childhood and should be continued to middle age and when possible into old age because exercise helps to make the most of diminishing physical capacity" (Fentem 1994).

This work did not examine whether adolescents participate in sufficient physical activity. In the study of Nupponen and Telama (1998), one third of the boys and one fifth of the girls had a sufficient physical activity habit when the criterion was at least four times a week, a total of four hours. Further studies of physical activity are needed in order to make scientifically based recommendations for Finnish adolescents.

6.5 Conclusions

Knowledge of the health benefits of physical activity and the risk of declining activity in adolescence makes young adolescents an important target group for physical activity promotion programmes.

Based on this study, physical activity patterns during adolescence show changes in behaviour over a three-year period. Those participating in organised sports, ballgames and power types of sports appear to be more persistently active.

Health-related behaviours, especially smoking, as well as the type of school and educational achievement, have an impact on persistent activity. Physically active adolescents seem to live a healthier life and tend to be better educated.

Familial influence is mainly based on siblings' or co-twin's physical activity. Boys seem to be more active than girls.

Based on our findings, schools emerge as the key elements in promoting physical activity. The role of the parents decreases in late adolescence and friends become more important. Schools have the possibility to apply systematic physical education and therefore adolescents approaching the end of secondary schooling can be considered a potential "drop out group".

Girls should be a special target group for promoting physical activity during late adolescence, including those who do not take part in organised sports. Another very important target group for promoting health are persistently inactive youngsters. We should focus on finding new and appealing ways of organising physical activity for children and adolescents who are relatively inactive and perhaps have less talent for competitive sports. My opinion is that schools should not only increase physical education, but also improve the quality of classes on offer, in order to make them more attractive. This is one way to encourage participation in more organised sports.

Promoting physical activity among adolescents should lead to a healthier overall lifestyle. Any short-term economic gains achieved by cutting back on physical

education classes will be more than lost forty years on in the form of increased health care costs.

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APPENDIX 1

ORIGINAL QUESTIONS (TRANSLATED FROM FINNISH)

1 SEX

1. girl
2. boy

2 DATE OF BIRTH _____/_____19_____

3 CURRENT HEIGHT_____cm

4 CURRENT WEIGHT_____kg

12 WHICH OF YOU, YOURSELF OR YOUR TWIN, WAS BORN FIRST ?

1 my twin
2 me
3 I don't know

13 ARE YOU PRESENTLY ATTENDING SCHOOL OR STUDYING?

1 I don't go to school nor do I study ----> go to question 16
2 I go to school or study, I don't work
3 I go to school or study, but also work

14 WHAT KIND OF SCHOOL OR INSTITUTION DO YOU ATTEND?

1 comprehensive school
2 senior high-school
3 higher education, university
4 trade school (accounting-, technical-, agricultural-, etc. school)
5 vocational school [higher level than 4 above but below university level] (business school, engineering school, nursing school etc.)
6 job training program, vocational training or equivalent.
7 other school or institution, what?

16 IF YOU DON'T PRESENTLY STUDY OR ATTEND SCHOOL, WHAT DO YOU DO? I AM:

1 in temporary training in order to continue my studies
2 I work for pay
3 I'm serving in the military
4 I'm unemployed or laid-off
5 I'm at home
6 other, what? _____

18 WITH WHOM DO YOU SPEND MOST OF YOUR LEISURE TIME?

1 alone
2 with my twin
3 with my family
4 with one friend
5 with two of my friends
6 with a larger group

20 HAVE YOU EVER SMOKED (OR TRIED SMOKING)?

1 no ----> go to question 24
2 yes

21 HOW MANY CIGARETTES HAVE YOU SMOKED ALTOGETHER UP TO NOW?

1 none
2 only one
3 about 2-50
4 over 50

22 WHICH OF THE FOLLOWING BEST DESCRIBES YOUR CURRENT SMOKING HABITS?

1 I smoke once or more daily
2 I smoke once or more a week, but not every day
3 I smoke less often than once a week
4 I am trying to or have quit smoking
5 I have never smoked

24 HOW DO YOU VIEW YOUR HEALTH, IS IT PRESENTLY

1 very good
2 rather good
3 mediocre
4 rather poor
5 very poor

25 DO YOU HAVE SOME LONG TERM ILLNESS OR DISABILITY WHICH HINDERS YOUR DAILY ACTIVITIES?

1 no
2 yes, describe briefly what kind

_____

_____

26 DURING THE PAST SIX MONTHS HAVE YOU HAD ANY OF THE FOLLOWING SYMPTOMS AND IF SO, HOW OFTEN?

CIRCLE THE CLOSEST ALTERNATIVE FOR EACH SYMPTOM

	Seldom or not at all	About once a month	About once a week	Almost every day
Stomach pains	1	2	3	4
Tension or nervousness	1	2	3	4
Irritability or temper outbursts	1	2	3	4
Sleeping disorders	1	2	3	4
Headaches	1	2	3	4
Tremor	1	2	3	4
Fatigue or weakness	1	2	3	4
Dizziness	1	2	3	4
Back or neck pains	1	2	3	4
Blushing	1	2	3	4

28 WHAT KIND OF SPREAD DO YOU USE ON YOUR BREAD?

1 usually nothing
2 mostly margarine (list of typical Finnish brands)
3 mostly butter
4 butter/margarine mixtures (list of products)
5 light spreads (lower fat content than 2, list of products)
6 other, what? _____

32 HOW OFTEN DO YOU DRINK ALCOHOL? TRY TO INCLUDE THE TIMES WHEN YOU DRINK VERY SMALL QUANTITIES, E.G. HALF A BOTTLE OF LIGHT BEER OR A SIP OF WINE.

1 daily
2 couple of times a week
3 once a week
4 a couple of times a month
5 about once a month
6 about once every two months
7 3-4 times a year
8 once a year or less
9 I don't drink any alcohol

33 AND HOW OFTEN DO YOU GET REALLY DRUNK?

1 once a week or more
2 about 1-2 times a month
3 less often than that
4 never

34 AND HOW OFTEN DO YOU DRINK SO THAT YOU GET SLIGHTLY INTOXICATED?

1 once a week or more
2 about 1-2 times a month
3 less often than that
4 never

39 HOW DO YOU PERCEIVE YOUR PRESENT PHYSICAL FITNESS? IS IT

1 very good
2 rather good
3 satisfactory
4 rather poor
5 very poor

40 WHICH OF THE FOLLOWING ALTERNATIVES BEST DESCRIBES YOUR PRESENT SPORTS/FITNESS ACTIVITIES? I USUALLY DO SPORTS OR EXERCISE SO THAT:

1 I breathe hard and sweat profusely
2 I breathe rather hard and sweat somewhat
3 I don't breathe very hard and sweat but little
4 I don't sweat or breathe hard
5 I don't do sports or exercise during my free time

41 HOW OFTEN DO YOU EXERCISE OR DO SPORTS DURING YOUR FREE TIME?
(SCHOOL PHYSICAL ACTIVITIES DON'T COUNT HERE)

1 not at all
2 less than once a month
3 1-2 times a month
4 about once a week
5 2-3 times a week

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