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Pertti Huotari

PHYSICAL FITNESS AND LEISURE-TIME PHYSICAL ACTIVITY IN ADOLESCENCE AND IN ADULTHOOD

-A 25-YEAR SECULAR TREND AND FOLLOW-UP STUDY

LIKES Foundation for Sport and Health Sciences

Jyväskylä 2012

ABSTRACT

Huotari, Pertti
Physical fitness and leisure-time physical activity in adolescence and in adulthood – A 25-year secular trend and follow-up study
Jyväskylä: University of Jyväskylä, 2011, 108 p.
LIKES - Research Reports on Sport and Health 255
ISSN 0357-2498
ISBN print 978-951-790-308-0 ISBN PDF 978-951-790-311-0

The purpose of the present study was to investigate the secular changes in physical fitness determined by leisure-time physical activity among Finnish adolescents and how physical fitness and leisure-time physical activity in adolescence predict leisure time-physical activity and self-estimated fitness in adulthood. In 1976 and in 2001, trained measuring teams carried out measurements of physical fitness and leisure-time physical activity among 9- to 21-year-old Finnish adolescents in their schools. In 1976 (n=2796) data were collected from 56 comprehensive and high schools and in 2001 (n=1042) from 17 of the schools that participated in 1976 measurements. In addition, in 2001, a follow-up questionnaire was collected from 1525 37- to 43-year-old adults who had taken part in the fitness tests or answered the questionnaire at age 12-18 in 1976. The secular trend study showed that aerobic fitness had declined and muscular fitness slightly improved among Finnish adolescents during the 25- year period. Polarization in fitness had increased over the period and participation in leisure-time physical activity was a stronger determinant of fitness in 2001 than 1976. In the follow-up study leisure-time physical activity in adolescence predicted leisure-time physical activity and self-estimated fitness in adulthood. The association between leisure-time physical activity in adolescence and leisure-time physical activity in adulthood was higher from age 16-18 to 41-43- years than from age 12-15- to 37-40- years. Physical fitness in adolescence predicted leisure-time physical activity in adulthood among males but not among females. In addition, adolescents who were physically active or had a high fitness level gave higher estimations of their physical fitness in adulthood than adolescents who were physically inactive or had a low fitness level. On the basis of both the secular trend and follow-up studies, active participation in leisure-time physical activity is essential for maintaining a high level of physical fitness from adolescence to adulthood. The fitness level of physically active adolescents is good whereas that of physically inactive adolescents is alarming. The findings of this study support the view that it is important to enhance adolescents' leisure-time physical activity. Due to the increased polarization in fitness, as determined by physical activity, more attention should be paid to the level of physical activity among the most inactive adolescents.

Keywords: physical fitness, physical activity, adolescents, secular trend, follow-up

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LIKES Research Reports on Sport and Health 255
Editors Eino Havas and Tuija Tammelin

Distribution LIKES - Research Center
Viitaniementie 15a
40720 Jyväskylä

ISBN print 978-951-790-308-0 ISBN PDF 978-951-790-311-0
ISSN 0357-2498

Printing Kopijyvä oy, Jyväskylä

ACKNOWLEDGEMENTS

This study was carried out in the Department of Sport Sciences, University of Jyväskylä. There are several persons who have supported me in realizing this study and to whom I would want to express my warmest thanks.

I am deeply grateful to my three supervisors, Emeritus Professor Heimo Nupponen, Emeritus Professor Lauri Laakso and Professor Urho Kujala for their skilful guidance and inspiration throughout the study. I have been privileged to have been able to work with them. I want also express my warmest thanks to Väinö Varstala for his important guidance at the beginning of the study.

I would want also thank the reviewers of my thesis, Emeritus Professor Ilkka Vuori and Professor Toivo Jürimae for their thorough review and constructive criticism. I also wish to thank Professor Tommi Vasankari for agreeing to be my opponent.

I owe my deepest gratitude to my co-author, Headmaster of Pajulahti Sport Institute Lasse Mikkelsson, for his untiring work in the data collection of this research project. I also want to thank Mikko Pehkonen, Susanna Parkkisenniemi and Hannu Soini for help to perform the fitness tests in the field.

Warm thanks go to the Principals at the Department of Sport Sciences, Professor Pauli Rintala and lecturer Kalervo Ilmanen for their helpful and positive attitudes to this research as well as to my colleagues at the Department of Sport Sciences for their support and good co-operation. Additionally, I want to express my special thanks to technical assistants Esa Nykänen and Pekka Rahkonen and researcher Pertti Matilainen for their technical and statistical advice and help in various phases of the study. My thanks also go to Eino Havas, Tuija Tammelin and Martta Walker from LIKES - Research Center for their contribution with the final lay out of this thesis. The English language of the thesis and the original papers has been revised by Michael Freeman. Warm thank!

I also thank the funding organizations which have financially supported this study: LIKES – Foundation for Sport and Health, the Foundation of Sports Institute and the Ellen and Artturi Nyyssönen Foundation.

Finally, I express my sincere thanks to my father and my late mother who always encouraged and supported me during my education. My dearest debt of gratitude goes to my wife Kati for being such a truly wonderful partner in life and my children Sanni, Topias and Lukas for their patience during all years of this study. They have reminded me what is really important. I dedicate this thesis to my family.

Jyväskylä, January 10th, 2012

Pertti Huotari

LIST OF ORIGINAL PUBLICATIONS

The present thesis is based on the following original papers which are referred to in the text by their roman numerals

I Huotari, P., Nupponen, H., Laakso, L., Kujala, U. 2010. Secular trends in aerobic fitness performance in 13-18-year-old adolescents from 1976 to 2001. British Journal of Sports Medicine 44, 968-972.

II Huotari, P., Nupponen, H., Laakso, L., Kujala, U. 2010. Secular trends in muscular fitness among Finnish adolescents. Scandinavian Journal of Public Health 38, 739-747.

III Huotari, P., Nupponen, H., Mikkelsson, L., Laakso, L., Kujala, U. 2011. Adolescent physical fitness and activity as predictors of adulthood activity. Journal of Sport Sciences 29, 1135-1141.

IV Huotari, P., Mikkelsson, L., Laakso, L., Kujala, U., Nupponen, H. 2011. Physical activity and fitness in adolescence as predictors of self-estimated fitness in adulthood. Submitted for publication.

ABREVIATIONS

AFI	Aerobic fitness index
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
BMI	Body mass index
FI	Physical fitness index
LTPA	Leisure time physical activity
MFI	Muscular fitness index
PAI	Physical activity index
SEFI	Self-estimated fitness index
VO_2 max	Maximal oxygen uptake

CONTENTS

1 INTRODUCTION

Physical fitness is an important part of human functionality related to health and well-being, and favorable effects of physical activity on health and fitness have been extensively documented. (U.S. Department of Health and Human Services 2008).

Good aerobic capacity in particular seems to predict low risk for cardiovascular diseases and mortality (Blair *et al.* 1989; Blair *et al.* 1996). Physical activity has beneficial effects on chronic disease risk factors already during childhood and adolescence (Eisenmann 2004; Froberg & Andersen 2005). Furthermore, physical activity promotes overall health and fitness, and physically active adolescents also seem to have higher probability of a healthier adulthood. (U.S. Department of Health and Human Services 2008.)

There is evidence that the level of aerobic fitness has declined among recruits over time in Finland (Santtila *et al.* 2006) and worldwide among adolescents (Wedderkopp *et al.* 2004; Malina 2007; Albon *et al.* 2010). Simultaneously an increase in participation in leisure-time physical activity has been reported among adolescents in Finland (Laakso *et al.* 2008). However, no consistent trends for participation in organized sport across different countries have been observed (Westerståhl *et al.* 2003a; Dollman *et al.* 2005). According to a use-of-time survey, screen time increased notably from the 1970s to the year 2000 among Finnish adolescents (Niemi *et al.* 1979; Statistics Finland 2007). In general, technological change during the last few decades has been rapid, and this is probably the main reason for the more sedentary lifestyle found among adolescents, with its effects on physical activity (Sallis *et al.* 2000) and possibly also on physical fitness. However over the last two decades in adults in Finland, the proportion of wholly sedentary person has decreased and participation in leisure-time physical activity has increased (Husu *et al.* 2011).

School physical education has played a notable role in the promotion of physical activity and a physically active lifestyle among children and adolescents. Physi-

cal education lessons in school have been an important way of stimulating interest in physical activity and sport among all children and adolescents regardless of their socio-economic status (National Core Curriculum for Basic Education 2004).

The continuity of physical activity has been, and remains, an important goal in the national core curriculum of physical education in Finland, and students have had opportunities to practise a wide range of different sports skills during their school years. It is widely thought that the versatile sports skills practised during one's school years may be the good preparation for a physically active lifestyle in adulthood. (National Core Curriculum for Upper Secondary School 2003; National Core Curriculum for Basic Education 2004.) Also fitness tests of various have been in use for a long time in Finnish schools and have also been utilized for motivating students to engage in physical activity and for the evaluation of physical education. Although the purpose of such tests has varied over time with the goals of school physical education, measurements of physical fitness in children and adolescents have been a common practice in school physical education. The time interval between the assessments of studied here was 25 years. In 1976 the main aim of physical education was to develop physical-motor fitness, whereas in 2001 the aims of physical education were more health-related. (Nupponen 1981; National Core Curriculum for Basic Education 1994; National Core Curriculum for Upper Secondary School 1994.)

Secular trends in health-related fitness components have been reported among children and adolescents around the world. Despite increasing participation in organized leisure-time physical activity, recent research clearly shows a declining trend in aerobic fitness performance (Wedderkopp *et al.* 2004; Malina 2007; Albon *et al.* 2010; Dyrstad *et al.* 2011) and slightly improved or unchanged muscular fitness performance (Tomkinson 2007; Volbekienė & Griciūtė 2007). In addition, physical fitness and leisure-time physical activity have been shown to track from adolescence to adulthood (Malina 2001; Telama 2009).

In Finland we lack information about long-term secular changes in physical fitness among adolescents. In addition, the follow-up studies of physical activity and fitness from youth to adulthood are rare. The present study produces information about the long-term changes in adolescents' physical fitness and the associations between physical activity and fitness from youth to adulthood utilizing cross-sectional and follow-up data collected in 1976 and 2001.

2 REVIEW OF THE LITERATURE

2.1 Definitions of physical fitness and its secular changes

Although there is no universally agreed definition of fitness and its components, many definitions have been presented. The World Health Organization has defined fitness as the ability to perform muscular work satisfactorily (WHO 1968) whereas for Caspersen *et al.* (1985) fitness is a set of attributes that people have or achieve. Bouchard *et al.* (2007, 13-14) determine fitness as acceptable performance by an individual of a given physical task in a specific physical, social and psychological environment. Physiologically fitness is characterized by a person's capability to function in and adapt to physical exercise and can be demonstrated through the operation of body systems associated with energy supply and energy transmission, circulation and respiration, and the performance of muscles and other soft tissues (Åstrand et al. 2003, 238).

Fitness has been divided into health and skill-related fitness of which the health-related components are cardiorespiratory endurance, muscular endurance, muscular strength, body composition and flexibility, while skill-related fitness concerns agility, balance, coordination, speed, power and reaction time (Pate 1983; Caspersen *et al.* 1985). In another definition fitness is categorized with a focus on either performance or health. The performance-related components of fitness are those that are necessary for maximal sports performance in athletic competition and thus include motor skills, cardiorespiratory capacity, muscular strength, speed, power or endurance, body size, body composition, motivation, and nutritional status. In contrast, in the health-related focus the components of fitness of interest relate to health and the benefits of a physically active lifestyle, and include many components such as cardiorespiratory endurance, muscular strength and endurance, flexibility, and body composition. In addition to this physical fitness is determined by several other variables, including habitual physical activity level, diet, and heredity (Bouchard *et al.* 1988, 6-7; Bouchard *et al.* 2007, 13-14).

There are many ways to assess the different aspects of fitness. A fitness assessment should be specific to the particular aspect being measured, to the population being examined, and the reasons why they are tested (Skinner *et al.* 1988; ACSM 2006). The worldwide standardization of measures of physical fitness started in connection with the Tokyo Olympic Games in 1964, and after lengthy- and extensive period of research and development, the ICSPFT (International Committee for the Standardization of Physical Fitness Tests) gave recommendations unified measurements. The tests used in this study conformed to the international standards for assessments, and are described in detail in appendix 3. (Larson 1974.)

2.1.1 Aerobic fitness

Aerobic or cardiorespiratory fitness is a health-related component of physical fitness that relates to the ability of the circulatory and respiratory systems to supply fuel during sustained physical activity and to eliminate fatigue products after supplying fuel (Howley & Franks 1997, 23-24). It can be defined physiologically as maximal oxygen uptake (VO_2 max), the highest rate at which skeletal muscle cells can utilize oxygen in the provision of energy for locomotion (Rowland 2005, 89-90). Aerobic fitness performance, such as long-distance running, correlates with VO_2 max and is influenced by a multitude of factors as heredity, training, gender, age, body fat and activity (Sharkey 1997, 76-80).

The course of childhood is marked by improvement in aerobic fitness performance and by progressive enlargement of the system components that determine VO_2 max as lungs, heart and skeletal muscle. Due to this development, the absolute values of maximal aerobic power increase as the child grows. Between the ages of 6 and 12 years, the VO_2 max of a boy more than doubles. For females, the average values are lower than those of males at the same chronological age. At puberty the rise in VO_2 max accelerates in males while values in females plateau. A progressive decline in mass-relative VO_2 max has been observed among girls from age 8 years on, and at age 15 relative VO_2 max is 20% lower in girls than boys. In boys no substantial changes in mass-relative VO_2 max have been observed. (Armstrong & Welsman 2001; Rowland 2005, 90-91.)

Aerobic fitness, defined also as the maximal capacity to take in, transport and utilize oxygen, is best measured by the so called VO_2 max test in a laboratory (Sharkey 1997, 72). Aerobic fitness can also be estimated with a simple, inexpensive field test such as the 1-mile walking test or 1.5 mile running test (Sharkey 1997, 72). In Finland, in schools, long-distance running tests and, among adults, the 2 km walking test have been used for many years (Nupponen 1981; Oja *et al.* 2010). These methods may result in errors at the individual level, although they work rather well at the group level, for example in schools. Previous

research suggests that running tests have acceptable validity and reliability (Simons *et al.* 1982; Safrit 1990).

Although only a very small change in young people's aerobic fitness has been found (Amstrong *et al.* 2011), their aerobic performance has markedly declined over the last few decades (Wedderkopp *et al.* 2004; Malina 2007; Albon *et al.* 2010; Dyrstad *et al.* 2011). In Finland, aerobic fitness performance has declined among military service conscripts during recent decades (Santtila *et al.* 2006), while information on long-term changes in aerobic fitness among school aged adolescents is lacking. In adolescents, aerobic performance involving the transport of body mass is important for health and well-being and for participation in sports (Armstrong *et al.* 2011). Because the previous secular trend studies mainly describe historical changes in the mean values of aerobic performance, it is not clear whether the changes in performance have been uniform over time. However, many of these secular trend studies suggest that such decline have been greater in the least fit children and adolescents. (Wedderkopp *et al.* 2004; Albon *et al.* 2010; Andersen *et al.* 2010.)

2.1.2 Muscular fitness

Muscle strength and muscle endurance are highly related in many activities and concern the ability of a muscle group to contract against a resistance, as in the amount of weight moved or in holding against a resistance (Falls *et al.* 1980, 60-61). Muscle strength is determined as the maximal force that can be exerted in a single maximal contraction. In contrast, muscle endurance refers to the ability to sustain the repetition of submaximal contractions or sub maximal holding time (isometric endurance) (Sharkey 1997, 138-139). The essential components of muscular fitness are strength, muscular endurance and flexibility, along with power, speed, agility and balance (Sharkey 1997, 136). Biological maturation, body size and composition are associated with strength characteristics although the associations vary by sex, age and the various strength components (Beunen 1997, 205).

Muscles contain numerous fibres and the amount of muscle fibres is fixed at or soon after birth. Between the ages of one year and adolescence fibre diameter increases almost threefold. In addition, as children grow muscle fibres become larger (hypertrophy), increasing muscle size. This muscle hypertrophy is reflected in an increase in total-body muscle mass during the years of growth. Estimated muscle mass rises linearly with age in the prepubertal years, with only slightly higher mean values in boys than in girls. At puberty, due to maturation androgenic hormones cause a rise in the rate of muscle growth in boys while minimal changes are seen in girls. (Rowland 2005, 89-90.) According to Beunen (1997, 205) age changes are demonstrated with a clear adolescent growth spurt in males for static strength, explosive strength and functional strength, and this strength spurt occurs 0.5 to 1.0 years after age at peak height velocity. Sharkey

(1997, 139) has estimated that in later adolescence women have half the arm and shoulder strength of their male counterparts and 30% less leg strength.

A number of possibilities are available for the measurement of muscle strength and endurance. Muscle strength is generally assessed by sophisticated laboratory methods such as cable tensiometry, dynamomethry, 1-RM (repetition max) methods for maximal strength and computerized isokinetic dynamometers. Dynamic muscular endurance is measured by the maximum number of repetitions that can be executed during a given exercise. (Howley & Franks 1997, 238-239.) The most common ways to measure muscular endurance in schools among Finnish adolescents have been the sit-up test for abdominal muscles and push-up or pull-up / flexing arm hang tests for the measure of the muscle endurance capacity in the upper body (Nupponen 1981). Muscular power has been measured by the vertical jump test and in addition to this long broad jump and 5-jump tests have been used in Finnish schools (Nupponen 1981; Sharkey 1997, 147).

In previous secular trend studies a slight increase in sit-up scores has been found among Lithuanian youth but a decrease among Swedish youth (Westerstahl *et al.* 2003b; Volbekienė & Griciūtė 2007). Although a positive secular trend in strength characteristics has been observed from the 1980s onwards, these changes are reduced when secular changes in stature and weight are considered (Beunen 1997, 205). Barnekow-Bergkvist *et al.* (1998) showed in their follow-up study that the explanatory power of muscular performance at age 34 from muscular fitness predictors at age 16 varied between 10% and 56%, depending on the test used, and in general it was lower in men than women.

2.1.3 Flexibility

Flexibility is an integral and separate aspect of fitness (Fleishman 1964). Flexibility and joint stability are highly dependent on the structure of the joint as well as the strength and number of ligaments and muscles spanning the joint. It is the ability of a joint, or series of joints, to move through a full range of motion (ROM) without injury. Adequate levels of flexibility are needed for the maintenance of functional independence and performance of activities of daily living. (Heyward 2002, 228.)

The sit-and-reach-test is commonly used measure of flexibility, and measures the flexibility of the lower back, hip and upper thigh. Among boys the mean scores of sit-and-reach-test are stable from 5 through 8 years, declining thereafter until 12-13 years and then increasing through age 18. In girls the stable phase lasts from 5 to 11 years, increases to age 14 and thereafter reaches a plateau. In general, girls are more flexible than boys at all ages and the sex difference is the greatest during the adolescent growth spurt and sexual maturation. (Malina & Bouchard 1991, 195-196.)

2.1.4 Speed, agility and power

Skill-related fitness includes fitness elements such as speed, agility, power, balance and coordination (Caspersen *et al.* 1985). Compared to health-related fitness, skill-related fitness is less related to health and more related to the ability to learn sports and other kinds of physical skills or athletic ability (Pate 1983; Caspersen *et al.* 1985; Corbin & Lindsey 2004, 133-134). Skill-related fitness abilities should not be confused with physical skills. Physical skills are specific physical tasks, such as catching, throwing, jumping and running or other skills as swimming or skiing. In contrast, skill-related fitness abilities, such as speed, agility or power help in the learning of these particular skills. (Corbin & Lindsey 2004, 133-134.)

Speed is defined according to the ability to perform a movement within a short period of time, and it is usually divided into reaction speed, explosive speed and movement speed. In contrast, agility relates to the ability to rapidly change the position of the entire body in space with speed and accuracy, and power refers to the rate at which one can perform work. (Caspersen *et al.* 1985.) Due to differences in maturation the best age for the development of these skill-related fitness items is difficult to determine. Although the predispositions for motor learning seems best up to early adulthood, the period before puberty (7-12 years) is nevertheless used for appropriate stimuli with regard to coordination and speed (Hirtz & Starosta 2002).

As with muscular strength, in the prepubertal years short running velocity is slightly better in boys than girls. Thereafter, up to age 17, the rate of running velocity improves in boys while in girls it stops or even decline at age 13-14. (Malina & Bouchard 1991, 193-195.) Gender differences have been found in speed and the agility-related shuttle run, although the development curves are fairly inconsistent. However, sex differences in the shuttle-run test are small from age 5 to 7, after which boys performed better and the difference increases with age. As with the measurement of explosive power, performance in the standing broad jump increases linearly in both sexes with age until 12-13 years, the difference between the sexes remaining relatively small during childhood. Thereafter, in girls the levels of performance reaches a plateau and then declines whereas in boys it increases sharply. (Malina & Bouchard, 1991, 192-196; Nupponen 1997, 122.) In previous secular trend studies Przeweda (2000) reported 0.17% improvement per annum during a 10-year period in the 4 x 10 m agility shuttle run among 7- to 19-year-old Polish youth. In his review study on strength and speed tests Tomkinson (2007) concluded that relative to the secular changes found in aerobic fitness test performance, the secular changes in anaerobic performance are considerably smaller.

2.1.5 Body composition

Body composition is a key component of an individual's health and physical fitness profile. Obesity is an increasing health problem worldwide that is associated with morbidity and mortality, type 2 diabetes and many CVD risk factors. (U.S. Department of Health and Human Services 2008). The generally agreed way of measuring overweight and obesity is relative percentage body fat (% body fat), which is the proportion of fat in relation to body weight. The body mass index BMI is the most commonly-used measure to assess overweight or obesity in adults, and although without additional information BMI is not a great deal of use for children and adolescents, the use of BMI, calculated from the subject's weight and body height (kg/ m²), has achieved international acceptance. (Bretschneider & Naul 2002, 7.) However, BMI as an indicator of adiposity varies according to degree of body fatness and it is a reliable indicator of adiposity particularly among overweight children (Daniels *et al.* 2009).

Differences in BMI among thin children are possibly due to differences in fat-free mass such as bones, muscles, water, proteins and minerals. These differences in amounts of muscle and fat mass exist between the sexes during growth and maturation. Boys usually have more muscle mass and girls more fat mass. In addition, BMI is limited in its ability to assess adiposity as it does not distinguish between fat mass and lean body mass. It is possible that individuals with increased muscle mass or with decreased lean body mass and increased adiposity may be misclassified by a BMI assessment. However, BMI has several benefits as an instrument to evaluate overweight in adolescents because it is cheap and easy to use in practice, as in school settings. (Daniels *et al.* 2009.)

Overweight and obesity among children and adolescents has increased during last few decades worldwide (WHO 2000). In her secular trend study Kautiainen *et al.* (2002) found an increasing trend towards overweight and obesity among Finnish adolescents from 1977 to 1999. During this time period overweight and obesity increased in all age groups, the largest increase among boys being in the group of 12- to 14-year-olds and among girls in the group of 14- to 18-year-olds. Comparison of the BMI distributions showed that there was little or no change over time at the lower BMI levels, but increasing differences at the upper end of the distributions. According to international reference values, the prevalence of overweight increased in boys from 7.2% to 16.7%, and in girls from 4.0% to 9.8%. In addition, the prevalence of obesity in boys increased from 1.1% to 2.7% and in girls from 0.4% to 1.4%. (Kautiainen *et al.* 2002.)

It has been shown that overweight has an inverse association with physical fitness and that poor fitness is related to impaired health already in adolescence (Eisenmann *et al.* 2007; Fogelholm *et al.* 2008). Fogelholm *et al.* (2008) investigated physical fitness between normal weight and overweight adolescents and found that overweight had the most negative association with cardiorespiratory

and muscle endurance, and the explosive power tests. A weak association was found with the ball skill test and no association with the sit-and-reach test. Although sedentary behaviour and low physical activity may be factors linking obesity and low physical fitness (Nelson *et al.* 2006; Fogelholm *et al.* 2008), obesity by itself could impair physical performance in activities involving carrying of body weight (Malina 1995).

2.1.6 Self-estimated physical fitness

Physical self-perception is part of the multidimensional concept of self-esteem. Physical self-perception is divided into body image and perceptions of physical strength, fitness and sport competence (Harter 1985: Fox & Corbin 1989). Self-perceptions are most negative in early adolescence, becoming more positive during late adolescence and early adulthood in both sexes. On the basis of the physical self-perception profile model (PSPP- model) (Fox & Corbin 1989; Sonstroem *et al.* 1992), self-estimated physical fitness is one's perception of one's physical fitness and it includes various health-related fitness components, such as endurance, strength, speed and flexibility (Marsh & Redmayne 1994; Mikkelsson *et al.* 2005). Previous results obtained with the PSPP-model have shown that in the adult population males have higher levels of physical self-perceptions than females (Fox & Corbin 1989; Sonstroem *et al.* 1992; Hayes *et al.* 1999).

Studies of self-estimated fitness have shown an association between measured and self-estimated fitness among adults (Mikkelsson *et al.* 2005) children and adolescents (Delignieres *et al.* 1994; Lamb & Hayworth 1998; Jürimäe & Saar 2003). In the study by Marsh & Redmayne (1994) among 13- to 14-year-olds, the correlation coefficient between physical fitness and physical self-concept was 0.71, the coefficients between the self-concept responses and four components of physical fitness indicators varying from 0.40 to 0.72. A previous cross-sectional study with a small adult population found a moderate association between measured and self-estimated fitness in adults. Correlation coefficient between the measured and self-estimated fitness indices was 0.56. (Mikkelsson *et al.* 2005.) However, longitudinal evidence on the association between measured and self-estimated fitness is scarce.

2.2 Physical activity

2.2.1 Definition of physical activity

Bouchard *et al.* (2007) defined physical activity as behavior in which the bodily movement produced by the skeletal muscles results in a substantial increase over resting energy expenditure. They divided this broad concept into leisure-time

physical activity including exercise and sport, transportation, occupational work and chores. The physical activity and movement of a sedentary person accounted for about 25% of daily energy expenditure whereas it could be as high as 50% for a very physically active person, such as an endurance athlete. (Bouchard *et al.* 2007) Physical activity displays wide variation between males and females, across age groups, and across different ethnic groups (Katzmarzyk 2007, 38).

2.2.2 Leisure-time physical activity

After completion of work or school, travelling, domestic chores, and personal hygiene, the average person has 3 to 4 hours of leisure or free time per day. One of numerous ways to use this leisure time is in a physically active way. Leisure-time physical activity (LTPA) is an activity undertaken in the individual's free time that increases total daily energy expenditure. The type of activity is selected on the basis of personal interests, as motivation is essential for the activity (Bouchard *et al.* 2007, 12-13). *Exercise* is a form of LTPA that is usually performed repeatedly over an extended period of time with a specific external objective such as the improvement of physical performance, fitness or health. An exercise regimen typically includes recommendations as to the mode, intensity, frequency, and duration of activity (Bouchard *et al.* 2007, 12-13). Bouchard *et al.* (2007, 13) present six intensity levels of endurance exercise. For each level there is a specific relationship between exercise intensity and heart rate expressed as a percentage of the maximal attainable heart rate. The six levels with the percentage of maximal attainable heart rate are as follows: very light (25-60%), light (60%), moderate (70%), hard (80%), very hard (90%) and maximal (100%). *Sport* usually refers to competitive activity undertaken in the context of rules defined by an international regulatory agency. However, in some contexts the term sport may also include exercise and recreation (Bouchard *et al.* 2007, 12-13).

Participation in a sport club is a form of leisure-time physical activity providing an opportunity for organized, competitive and social participation (Eime *et al.* 2009). Organized sport participation has been used as an item of physical activity in many studies in Finland and elsewhere, and has been shown to have rather good reliability, but problematic validity, if energy expenditure is taken as a criterion of validity (Telama & Yang 2000). HBSC (Health Behavior Study in School-Aged Children) study, which has been on-going since the year 1978, provides a measure of sport club participation among young people in the WHO European Region and North America (Kannas 2004, 3-5). The HBSC-study has investigated trends in physical activity among adolescents, including changes in youth sport club participation.

2.2.3 Physical activity and youth

Improving and maintaining physical activity as a child may provide both immediate and long-term health benefits. The benefits of regular physical activity for

children and adolescents could include, at least, mental well-being, development of motor skills, psychological development and social relationships. Although there is much evidence in favor of the health benefits of physical activity among adults, less scientific documentation exists in for this relationship among young people. However, in children and adolescents physical activity and regular physical activity can be expected to have long-term useful outcomes as several diseases in adulthood that may be influenced by insufficient physical activity (obesity, CVD diseases) often have their origins in the pediatric years. For this reason ways by which physical activity habits can be instilled and sustained in sedentary children and adolescents need to be developed (Rowland 2007).

According to the basic recommendations given for physical activity, school-aged children and adolescents should be physically active on a moderate or vigorous intensity level for at least one to two hours daily, in a variety of ways suitable for each age group (Tammelin & Karvinen 2008; U.S Department of Health and Human Services 2008). Although there is evidence that the participation in leisure-time physical active has increased in many European countries during recent decades (Laakso *et al.* 2008), evidences on the amount of total physical activity, including both participation in LTPA and every-day physical activities, is lacking. However, during recent decades, the use of time has changed and the use of technological devices has increased among youth. In Finland, in the 1970s, total TV viewing time among adolescents was on average 1.30 hours/day, whereas in the past decade screen time is estimated to be as high as 5-6 hours/day (Statistics Finland 2007). Furthermore, the number of cars per capita increased from 0.2 to 0.4 between 1976 and 2001, and in the year 2000 over 60% of Finnish homes had a computer and almost all Finns aged 15-39 used a mobile telephone (Statistics Finland 2007). According to Brownson *et al.* (2005) the level of leisure-time physical activity in the United States has been relatively stable or has slightly increased, whereas physical activity related to work, transportation and home activities has declined. Furthermore, sedentary behavior has increased and these changes together have resulted in an overall trend towards a decline in total physical activity (Brownson *et al.* 2005).

Many previous studies have indentified the determinants of physical activity in youth. Sallis *et al.* (2000) provide a useful review study in this area, suggesting that the essential determinants include biological factors (age, gender, heredity), psychological factors (enjoyment and perceived competence), social factors (encouragement from parents and peers), demographic factors (as greater likelihood of activity in younger age, particularly in boys) and the physical environment (availability of facilities and programmes). These determinants should be taken into consideration when analyzing and interpreting the changes and differences in physical activity by age between males and females that have been documented in numerous studies. Some studies have indicated that activity declines with age, and that boys are more active than girls (Telama & Yang 2000; Kemper *et al.* 2001). The reasons for these gender differences are not clear but a previous

study suggests that a possible reason is that the timing of maturation between the sexes is different and also affects physical activity (Sherar *et al.* 2010). However, gender differences have strong cultural background and there is also wide variation in physical activity by age (Roberts *et al.* 2004).

It has been found that in Finland the gender difference is smaller than in many other countries and that in late adolescence girls are even more active than boys (Telama & Yang 2000). Boys take part in organized sport more than girls and this difference may account for the major part of the gender difference in overall physical activity. The frequency of participation in organized sport is the highest at age 12 and the decline steepest between ages 12 and 15 among males and between 15 and 18 among females. For males this decline largely represents participation in competitive sport whereas among female many noncompetitive organized activities such as gymnastics, dance and aerobics are also included. The physical activity of boys declines more than that of girls and with age activity shows greater polarization among boys than girls, meaning that the numbers both of very inactive and very active boys increase. (Telama & Yang 2000.)

Laakso *et al.* (2008) found that although leisure-time physical activity among youth increased from 1977 to 2007 – particularly in the form of participation in organized sport – and that the general trend in leisure-time physical activity seems to be towards organized activity, the share of unorganized spontaneous activity is declining. Persistent participation in youth sport can be argued to be a positive sign with respect to the adoption of a physically active lifestyle in adulthood. However, a negative aspect of this development is the fact that participation in organized sport is influenced to a significant extent by parental socioeconomic status, a tendency that has strengthened during last few decades. (Laakso *et al.* 2008.)

2.2.4 Physical activity in adulthood

According to the recommendation for physical activity in adults aged 18-65 years, adults should accumulate 30 minutes or more of moderate-intensity physical activity on most days of the week. To promote and maintain health, all healthy adults need moderate-intensity physical activity for a minimum of 150 min per week. In addition to aerobic activity, adults will benefit from activities that maintain or increase muscular strength and endurance for a minimum of two days per week. (U.S. Department of Health and Human Services 2008; Husu *et al.* 2011.)

Large population-based trend data suggest that, among Finnish adults during the past 30 years, occupational and commuting physical activity has decreased although leisure-time physical activity has increased (Borodulin *et al.* 2008). Previous studies conducted both by objective and questionnaire methods have shown that women attain the recommendation of physical activity better than men, although the differences between the sexes are small (Borodulin *et al.* 2008;

Hirvensalo *et al.* 2011). In addition, high education and high socio-economic status are associated with a greater amount of objectively assessed leisure-time physical activity (Hirvensalo *et al.* 2011).

According to surveys of national physical activity and fitness among Finns survey conducted between the year 2000 and 2010, participation in leisure-time physical activity increased over this period. The proportion of those who participated in leisure-time physical activity (lasting ≥ 30 min) at least four times a week, increased from 46% to 55%, while those who participated infrequently or not at all, declined from 17% to 10%. However, approximately one-half of the population aged 25-64 years is engaged in aerobic physical activity that fulfils the recommendation for health, while only 10% of this age group is also engaged in exercise to improve muscular strength at least twice a week. When approaching retirement age, only a few percent of the population meet the recommended level for health in both aerobic and muscular exercise. (Husu *et al.* 2011.)

2.3 Physical activity and fitness – relationships in youth and in adulthood and associations from adolescence into adulthood

Bouchard *et al.* (1994, 77) presented a model of the relationships between physical activity, health-related fitness and health in the adult population. Figure 1 shows that heredity regulates all the major components: physical activity, health-related fitness and health. The interaction of the major components means that habitual physical activity can influence fitness, which in turn may modify the level of habitual physical activity. The fittest people tend to be the most active and, with increasing fitness, individuals tend to become more active. Fitness is also related to health in a reciprocal manner, meaning not only that fitness influences health, but that health status influences both the habitual physical activity level and fitness level. However, level of fitness is not determined entirely by an individual's level of physical activity. Other lifestyle behaviors, social and physical environments, personal attributes and genetic factors also affect the major components of the model and determine their interrelationships. (Bouchard *et al.* 1994, 77.)

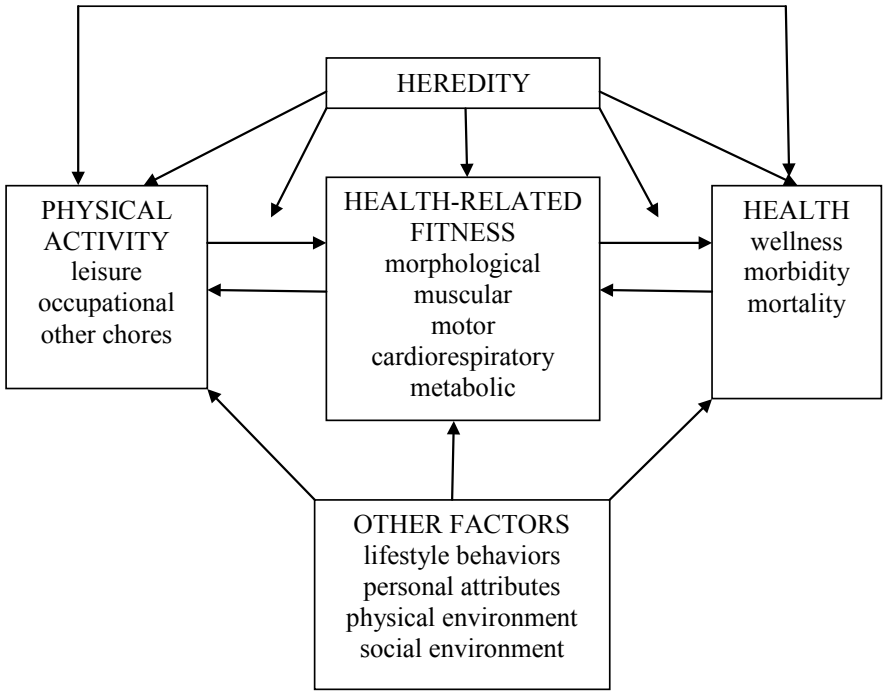


Figure 1 A model describing the relationships among habitual physical activity, health-related fitness, and health-status (Bouchard *et al.* 1994, 78).

The currently held view posits that childhood and adolescent physical activity and physical fitness may influence health status during childhood and adolescence and throughout adulthood (Malina 2001). In previous studies the potential relationships between physical activity and fitness in adolescence, and the longitudinal associations between adolescent physical activity and fitness and adult physical activity and fitness have been defined by pathways (Malina 2001; Twisk *et al.* 2002; Tammelin 2003).

2.3.1 Youth physical activity and youth physical fitness

Previous studies have shown only weak evidence for the link between physical activity and fitness in youth, and the results of these studies suggest that other factors besides physical activity also have a strong impact on physical fitness. Pate *et al.* (1990) investigated a nationally representative sample of third- and fourth-grade students and found a significant though moderate association between physical activity and fitness. Physical activity, age and gender accounted for 21% of the variance in performance of the 1.6 km run/walk test. In another study, after controlling for gender, physical activity accounted for only 3-11% of the variance in the health-related fitness items (Sallis *et al.* 1993). Katzmarzyk *et al.* (1998) found a significant low to moderate association between fitness and activity among 9- to 18-year-old Canadian adolescents. In their study, physical activity explained 11-21% of the variance in the physical fitness items. A large part of the variability (80-90%) in physical fitness was not accounted for by physical activity and the researchers concluded that changes in the biological and behavioral domains associated with normal growth, maturation and development from childhood throughout adolescence exert a significant influence on the physical fitness of children and adolescents. (Katzmarzyk *et al.* 1998.) In his review study, Malina (2001) suggests that more active youth are fitter, particularly in cardiovascular endurance tasks, although the methods of assessment and criteria for active and inactive youth vary among studies. Ara *et al.* (2004) found that, those who participate in regular and vigorous sport activities for at least 3 h per week have significantly better physical fitness compared to those who do not participate regularly in sport. The association between physical activity and fitness was found also to be stronger than that between overweight and fitness (Fogelholm *et al.* 2008). Previous research suggest that it is possible that level of physical fitness influences the level of physical activity because good fitness makes physical activity easy and enjoyable, and many physical activities improve and maintain fitness (Fogelholm *et al.* 2008).

2.3.2 Youth physical activity and adult physical activity

The potential relationship between adolescent physical activity and adult physical activity assumes that physical activity tracks from adolescence into adulthood (Malina 2001). Tracking is usually defined as a tendency of individuals to maintain their position within a group over time (Malina 1996). The tracking of physical activity is important from the viewpoint of physical education, and nowadays the promotion of a physically active lifestyle and life-long physical activity are the most common aims of physical education in many countries (Pühse & Gerber 2005, 50-719). It is expected that physical activity in adolescence, e.g in youth sport or in school physical education, will have a positive effect on public health. It is desirable that a high level of physical activity in adolescence tracks to adulthood (Telama 2009).

Spearman's rank order correlation has been the method most often used in physical activity tracking studies. Spearman's correlation indicates only the association between two assessments, but does not reveal about causality or determining factors: Correlation coefficients under 0.30 are considered low, 0.30-0.60 moderate and above 0.60 high. Another method for showing tracking is to divide the distribution of physical activity into tertiles, quartiles or quintiles, and then show by cross-tabulation or risk analyses the extent to which individuals have remained in the same position over time. The probability (risk or odds) or prevalence (%) of being physically inactive or active as an adult can be presented for different groups of adolescent physical activity. (Tammelin 2003, 24; Telama 2009.)

Previous studies have shown that LTPA in childhood and adolescence predicts LTPA in adulthood, and thus may influence population health (Barnekow-Bergkvist *et al.* 1998; Tammelin *et al.* 2003; Telama *et al.* 2005a). Longitudinal studies have shown a statistically significant but rather moderate or low association between adolescent and adult LTPA (Telama 2009). Many studies have focused on people aged 13 to 20 years, showing that stability seems to be lower from early childhood to adulthood than from adolescence to adulthood (Kemper *et al.* 2001). Also, association has been stronger among men than women (Barnekow-Bergkvist *et al.* 1998; Tammelin *et al.* 2003; Telama *et al.* 2005a).

2.3.3 Youth physical fitness and adult physical activity

Some short-term studies indicate that physical fitness during youth (10-18 years) may be predictive of LTPA levels in adulthood (Dennison *et al.* 1988; Glenmark *et al.* 1994; Barnekow-Bergkvist *et al.* 1998). Dennison *et al.* (1988) investigated the physical activity levels of 23- to 25-year-old men who had performed fitness tests as children or adolescents (10 to 11 years of age or 15 to 18 years of age). The results showed that the physically active adults had significantly better childhood physical fitness test scores than the inactives, and the risk of physical inactivity in young adulthood was linearly related to the number of low scores in the long-distance running and sit-up tests as children (Dennison *et al.* 1988). In another study in which the age interval was 11 years (from 16 to 27 years), aerobic capacity alone explained 31 % of the adult physical activity level in women and 24% in men (Glenmark *et al.* 1994). Strength performance further increased the predictive value for physical activity level in adulthood for women but not men. The researchers suggested that physical characteristics, physical performance and physical activity predicted the major portion of the variation in physical activity level in adult women, but not in adult men. (Glenmark *et al.* 1994.) Barnekow-Bergkvist *et al.* (1998) also reported that performance in physical tests at age 16 predicted physical activity at age 34 better among women than men. The level of explanation varied between 10% (9-min run test) and 56% (bench press test). They concluded that attitudes to sport and socio-demographic factors at a young age seem to influence adult physical activity habits and fitness in complex

ways, and facilitate identification of inactivity risk groups (Barnekow-Bergkvist *et al.* 1998).

2.3.4 Youth physical activity and fitness and adult self-estimated fitness

Previous studies have shown the relationship between physical activity in youth and physical fitness in adulthood to be meagre. Physical performance is strongly influenced by genetic factors, and only a minor part of adult physical capacity can be explained by other important factors, such as regular and continuous physical activity. (Barnekow-Bergkvist 1998.) The association between physical activity and indicators of physical fitness has been found to be on the same level in adults as in youth (Malina 2001). In a study of aging, the correlations between high-intensity leisure-time physical activity and cardiorespiratory fitness were 0.33 in males and 0.27 in females (Talbot *et al.* 2000). However, the magnitude of the relationship is reduced when the decline in the intensity of physical activity or when age and the BMI are statistically controlled for.

Longitudinal studies on physical fitness from adolescence to adulthood are scarce but indicate better tracking for fitness than for physical activity. Previous studies on the tracking of fitness have indicated that this relationship from youth to adulthood is moderate. Correlation coefficients for the tracking of flexibility and strength have been higher than for cardiorespiratory fitness. (Malina 2001.) For instance, Mikkelsson *et al.* (2006) studied the tracking of fitness from age 15 to age 40 and found the highest tracking correlations in the sit-and-reach test (r=0.74) for males and sit-up test (r=0.55) for females. However, maturity and growth are linked to the tracking of physical fitness and the interaction between individual differences in maturity status and fitness has to be taken into consideration in the interpretation of tracking results (Malina 1996; Malina 2001).

Studies on the relationships between physical activity and physical competence among adolescents and adults have indicated significant associations between these factors (Sonstroem *et al.* 1992; Hayes *et al.* 1999; Sallis *et al.* 2000), while physical activity level has been shown to be an important determinant of self-estimated physical fitness in adolescence and physical activity seems to increase self-perceptions of physical competence (Lintunen 1995.) Even participation in physical activity of relatively low frequency (2-5 hours/week) has been shown to be enough to generate high perceptions of fitness among active adolescents even if their actual fitness remained at the same level as that of their inactive counterparts (Lintunen 1995). Hayes *et al.* (1999) investigated gender differences in physical self-perceptions, global self-esteem and physical activity in adults and reported that males had higher levels of physical self-perceptions than females, although no gender difference was observed in physical activity level. In addition, previous results have shown that positive perception of competence in sports increases physical activity among adolescents and that to adapt to new modes of physical activity as adult, positive experiences in childhood and adolescence are

important. (Sallis *et al.* 2000; Tammelin *et al.* 2003.) It has been suggested that practice of a wide range of sports skills in childhood and adolescence may be the best preparation for adult physical activity as this may increase the probability that one of the activities will also continue into adulthood (Tammelin *et al.* 2003). However, despite the considerable evidence for a positive effect of long-standing physical activity and fitness on health and well-being, longitudinal evidence on the relationship between the level of physical activity and fitness in adolescence and the level of self-estimated fitness as an adult is lacking.

3 AIMS AND MODEL OF THE STUDY

The purpose of the present study was to investigate the secular changes in physical fitness determined by leisure-time physical activity among Finnish adolescents and how physical fitness and leisure-time physical activity in adolescence predict leisure time-physical activity and self-estimated fitness in adulthood.

The aims of the study were:

25-year secular trends

1. To evaluate 25-year secular trends in aerobic fitness performance (later also termed aerobic fitness) and its distributional changes in 13- to 18-year-old adolescents

2. To determine the 25-year secular trends in muscular fitness performance (later also termed muscular fitness) and its distributional changes in 13- to 16 year-old adolescents.

3. To study changes in leisure-time physical activity and BMI as the determinants of aerobic and muscular fitness performance.

25-year follow-up

4. To investigate how leisure-time physical activity and physical fitness (aerobic fitness and muscular fitness) in adolescence (age 12-18) predict adult leisure-time physical activity (age 37-43).

5. To examine how leisure-time physical activity and physical fitness in adolescence (age 12-18) are associated with self-estimated fitness as an adult (age 37-43)

The secular trends in physical fitness and associations between physical fitness and leisure-time physical activity were examined in two cross-sectional research populations in 1976 and 2001. In addition, longitudinal changes in leisure-time physical activity and its association with self-estimated physical fitness were evaluated. The numbers in figure 2 refer to the aims of the study.

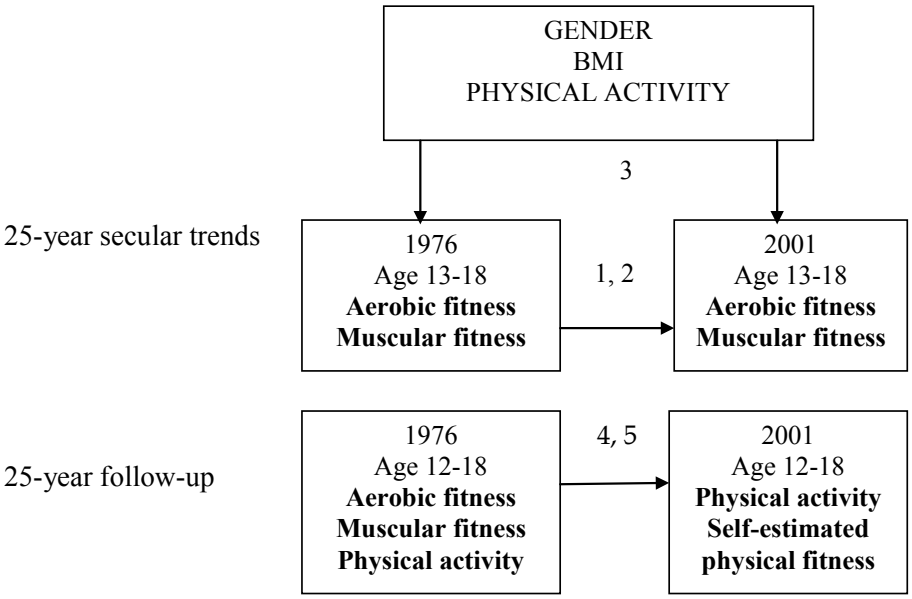


Figure 2 The model of the present study.

4 MATERIAL AND METHODS

4.1 Study population, data collection and characteristics of the participants in 1976 and 2001

In April-May of 1976, trained measuring teams carried out measurements of physical fitness and leisure-time physical activity among 2 796 Finnish adolescents aged 9- to 21 in their schools (figure 3). Data were collected from 56 schools comprising 40 comprehensive and 16 high schools. The sample was a four-phased stratified random sample and the schools were drawn from different geographical provinces (north, east, central, west), and included both urban and rural municipalities. The proportion of the participants from rural schools was 54%. In the first phase, a total of 20 towns and rural communities were randomly selected from the four geographical areas (west, east, middle and north) of Finland. A random sample of 56 schools matched for student numbers was taken from these towns and communities (to ensure correspondence in size of schools from towns and rural communities). The proportion of participating schools was 0.8% of all Finnish comprehensive schools. In the province of Central-Finland the proportion was 7 %. Classes were randomly selected and adolescents were chosen from either the beginning or the end of the alphabet, or, at the beginning of the measurement, they were lined up and chosen at equal intervals (every second or third etc.).

In April-May of 2001, another wave of cross-sectional data was collected by trained measuring teams from 17 comprehensive and high schools comprising 1041 11- to 18-year-old adolescents from comprehensive school (grades 5-9) and high school. The main aim was to carry out the data collection and measurements as far as possible in the same way as in 1976. The sample was a three-phased stratified random sample comprising 62% of the same- age population of 1976. In the first phase, 9 communes were selected randomly from the 20 communes that participated in 1976. Three of these were rural communes (<10000 residents) and the proportion of rural participants was 30%. In the second phase, 17 schools were selected from the schools which participated in 1976 and represented the same geographical provinces as in 1976. The proportions of participants were:

from Northern-Finland 19%, Eastern-Finland 23%, Western-Finland 18% and Central-Finland 40%. In the third phase the school classes were selected as in 1976. Appendices 1, 2 and 3 show the letters sent to the head-teachers of schools, physical education teachers and students' parents.

In addition to this, in 2001, a follow up questionnaire concerning subjects' LTPA was sent to 2396 34- to 46-year-old adults who had taken part in the fitness tests and/or answered the LTPA questionnaire in 1976. Of these, 1820 responded to the questionnaire. The final group in this study consisted of the 722 men and 803 women, who took part in both the baseline measurements at age 12-18 years in 1976 and returned the follow up questionnaire at age 37-43 years in 2001 (n=1525).

In the final study group, not all the subjects participated in all the tests. Either fitness test or baseline questionnaire data were available for all those who responded to the questionnaire in 2001 at age 37-43 years, although complete baseline data (both fitness tests and questionnaire) were available for only 209 participants, or 14% of the whole target group. The association between physical activity in adolescence and as adult was investigated in 1334 participants (616 males and 718 females), comprising 87% of the whole target group. The analyses between the fitness components and physical activity were carried out among 824 participants for aerobic fitness (54% of the whole target group), 1065 participants for muscular fitness (70% of the whole target group) and 463 participants for the fitness index (30% of the whole target group). In addition, subjects were divided into two groups according to age at baseline. In the younger age group the participants were followed from age 12-15 to age 37-40 -years and in the older group from age 16-18 to age 41-43 -years. The follow-up questionnaire response rate was 66% of those who participated in the baseline measurements. The study was approved by the Ethics Committee of the Central Finland Health Region. Before the tests a parental consent was obtained and participants were allowed to refuse to participate in the tests (appendix 4).

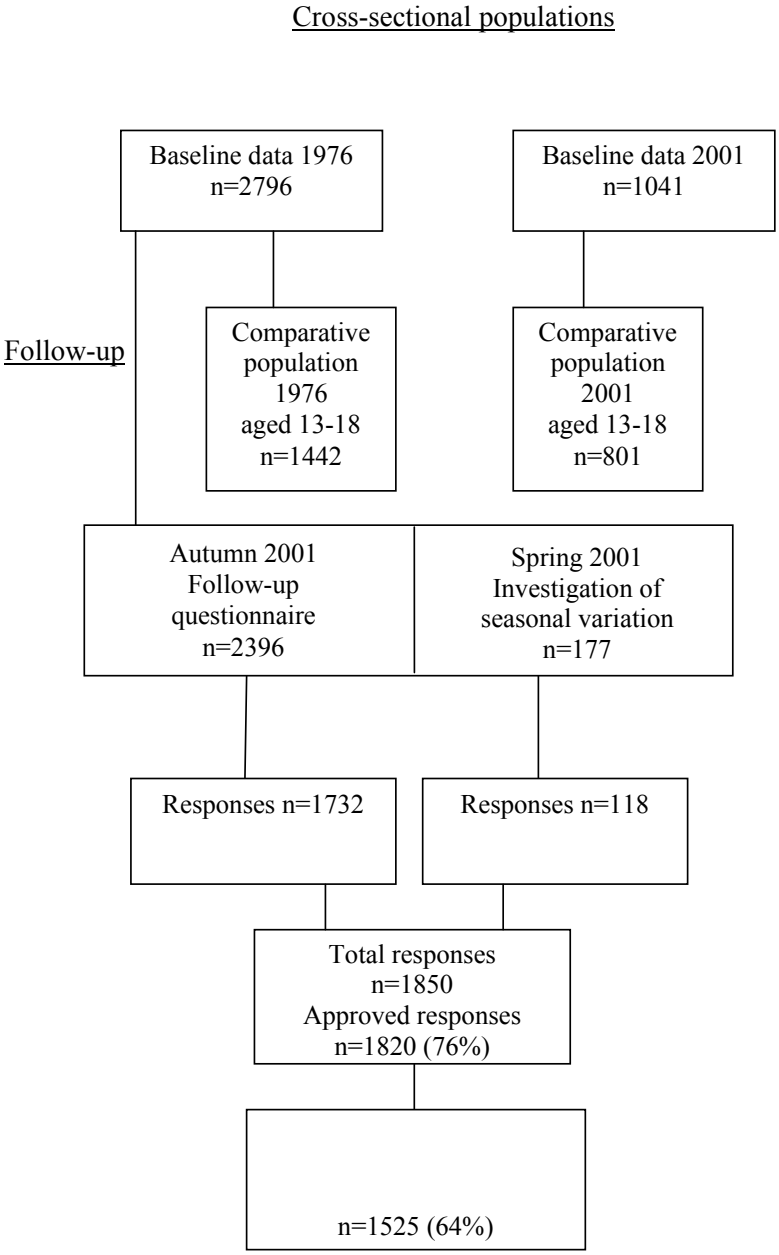


Figure 3 Participants of the present study in 1976 and in 2001.

The characteristics of the different study samples are shown in tables 1 and 2. Table 1 shows the characteristics of subjects who participated in the secular trend studies and table 2 those who participated in the follow-up studies.

Table 1 Characteristics of participants in the secular trend studies (papers I and II). Values are mean values and (standard deviations).

	Paper I				Paper II			
Characteristic	Boys 1976 n=384	Boys 2001 n=305	Girls 1976 n=333	Girls 2001 n=253	Boys 1976 n=312	Boys 2001 n=308	Girls 1976 n=331	Girls 2001 n=271
Age (years)	15.9 (1.4)	15.4 (1.3)	15.7 (1.4)	15.3 (1.3)	14.9 (1.1)	15.0 (1.0)	14.9 (1.0)	15.0 (1.0)
Height (cm)	170.0 (10.2)	170.8 (9.1)	163.2 (5.9)	162.0 (5.9)	166.4 (10.6)	169.5 (9.3)	161.8 (6.0)	162.5 (6.3)
Weight (kg)	58.3 (11.7)	60.8 (12.3)	53.0 (7.5)	54.8 (9.8)	54.2 (11.5)	58.9 (11.5)	52.3 (7.8)	54.3 (9.9)
BMI (kg/m²)	19.9 (2.5)	20.7 (3.2)	19.9 (2.4)	20.7 (3.3)	19.4 (2.5)	20.4 (3.0)	19.9 (2.5)	20.5 (3.3)
2000 m (s)	559 (110)	615 (132)						
1500 m (s)			494 (77)	523 (99)				
Sit-up (rep./30 s)					19.8 (4.2)	22.5 (5.0)	16.5 (3.7)	18.0 (5.0)
Pull-up/ (rep.)					5.1 (3.6)	4.2 (4.3)		
Flexed arm hang (s)							13.2 (10.3)	13.4 (12.5)
Standing broad jump (cm)					207.1 (27.4)	209.4 (29.2)	173.3 (21.4)	176.6 (23.0)
Agility shuttle run (s)					12.0 (1.0)	11.4 (1.2)	12.8 (1.0)	12.5 (1.1)
Participation in LTPA (%)								
<twice a week	30.3	13.0	31.9	15.2	26.8	13.8	30.6	16.5
2-6 times a week	44.1	54.0	44.0	50.8	41.0	54.4	38.2	50.9
Every day	25.6	33.0	24.1	34.0	32.2	31.8	31.2	32.6
Participation in sports clubs (%)	32.0	47.8	17.2	30.2	37.2	48.0	21.4	35.6

Paper I Secular trends in aerobic fitness performance in 13- to 18-year-old adolescents from 1976 to 2011.
Paper II Secular trends in muscular fitness among Finnish adolescents.

Table 2. Characteristics of participants in follow-up studies (papers III and IV). Values are mean values and (standard deviations).

	Paper III				Paper IV			
Characteristic	Males 12-18 y. n=722	Males 37-43 y. n=722	Females 12-18 y. n=803	Females 37-43 y. n=803	Males 12-18 y. n=613	Males 37-43 y. n=613	Females 12-18 y. n=705	Females 37-43 y. n=705
Age (years)	14.7 (1.6)	39.7 (1.6)	14.7 (1.6)	39.7 (1.6)	14.7 (1.6)	39.7 (1.6)	14.7 (1.6)	39.7 (1.6)
Height (cm)	168.1 (11.4)	179.8 (6.4)	162.1 (6.4)	165.8 (5.6)	168.3 (11.3)	179.9 (6.5)	162.0 (6.4)	165.8 (5.6)
Weight (kg)	55.6 (11.8)	83.3 (12.0)	52.1 (8.1)	66.2 (11.2)	55.5 (11.8)	83.2 (11.8)	52.2 (8.1)	66.2 (11.4)
BMI (kg/m²)	19.4 (2.3)	25.7 (3.3)	19.8 (2.5)	24.1 (3.8)	19.4 (2.3)	25.8 (3.3)	19.8 (2.5)	24.1 (3.8)
2000 m (s)	564 (110)				566 (109)			
1500m (s)			487 (76)				486 (76)	
Sit-up (rep./30 s)	20.4 (4.0)		16.7 (3.8)		20.4 (3.9)		16.7 (3.6)	
Pull-up (rep.)	5.7 (4.0)				5.8 (4.0)			
Flexed arm hang (s)			14.5 (10.0)				14.5 (10.0)	
Standing broad jump (cm)	213.5 (29.3)		175.1 (21.6)		212.9 (29.4)		175.0 (21.9)	
Agility shuttle run (s)	11.8 (9.0)		12.7 (9.2)		11.8 (8.9)		12.7 (9.3)	
Participation in LTPA (%)								
<once a week	13.7	27.7	10.6	17.8	13.6	27.9	10.4	17.2
1-6 times a week	59.4	68.7	60.3	74.7	57.9	68.0	60.0	75.4
Every day	26.9	3.6	29.1	7.5	28.5	4.1	29.6	7.4
Participation in sport clubs (%)	38.0	20.8	19.7	38.0	37.5	19.4	22.2	37.3

III Physical fitness and activity as predictors of activity in adulthood.
IV Physical fitness and activity in adolescence as predictors of self-estimated fitness in adulthood.

4.2 Measurements

4.2.1 Pre-tests

Measurements were pretested at both assessment points to examine the suitability of the fitness tests and questionnaire for the youngest participants. In addition, the measurement procedure was checked. In 1976 and in 2001, 25 students took part in the pre-tests.

The pre-tests indicated that more specific information about the tests needed to be given to the participants and that warming-up before the test should be performed with care. In addition, some of the questions in the questionnaire needed to be made more specific. The pre-tests were administered by four persons, but because it was subsequently decided that the results of the fitness tests be recorded by the tester rather than the students themselves, five persons would be needed. The students who participated in the pre-tests were not included in the actual research material.

In the follow-up, the pre-test questionnaire was sent to the 89 34- to 42-year-old participants who had answered the LTPA questionnaire in 1976. The questionnaire was returned by 53 participants. After this, some items were revised. Those who responded to the pre-test questionnaire were not included in the actual study.

4.2.2 Measurements of physical fitness

Identical fitness test procedures and information were used at both assessment points (appendices 5 and 6). The tests were conducted by a specially trained group in the participants' own schools during school hours. In all the indoor tests the participants wore light clothing and before the tests the same warming-up protocol was administered to all the groups of participants. Refusals to participate were allowed before the tests; however, only pupils with an illness or injury refused (non-participation due to diseases or injuries < 5%) (appendix 4). For both sexes the physical fitness tests comprised a standing broad jump (cm), sit-ups (times in 30 sec) and a 4 x 10m agility shuttle run. In addition, aerobic fitness performance was measured in boys by the 2 000 m and in girls by the 1 500 m running tests and, upper-body muscular fitness in girls by the flexed arm hang and in boys by pull-ups. The fitness test results were used to construct a gender-stratified fitness index (FI) which was formed by summing the age-adjusted z-scores. An aerobic fitness index (AFI) was calculated as the age-adjusted z-score for long distance running, 2 000 m for boys and 1 500 m for girls. A muscular fitness index (MFI) was calculated by summing the age-adjusted z-scores for the standing broad jump, sit-ups, pull-ups/ flexed arm hang and 4 x 10 m shuttle run.

Testers and the students themselves recorded the scores of the muscular fitness tests and physical education teachers the long distance running times on the student's own fitness card. The participants' weight and height were measured by school health nurses or the assessment teams with the calibrated steelyard and gauge used in school health care in Finland. Height and weight were measured to the nearest 1 cm and 0.5 kg. The fitness test instructions given are presented in appendix 6 and the student's fitness card in appendix 7.

In the follow-up study as an adult, participants estimated their own physical fitness themselves by responding for the two questions shown in table 12 and in appendix 9 (questions 37 and 49). The participants estimated which category of physical fitness they belong to now when compared to persons of the same age and sex and estimated performances which they are able to perform in a varied terrain.

4.2.3 Measurements of leisure-time physical activity

In both 1976 and 2001, adolescents' leisure-time physical activity and participation in a sports club were recorded using self-report questionnaires that were administered individually in connection with the fitness test. The questions concerned the frequency and intensity of leisure-time physical activity, participation in sport club training and participation in competitive sport events and in different sports. The frequency and intensity of leisure-time physical activity was asked by the question "How many times a week do you participate in leisure-time physical activity of at least 30 min duration so that you feel breathless?" This question was coded on a 6-point response scale (0=not at all, 1=less than once a month, 2= once a month, 3= 2-3 times a month, 4=once a week, 5= 2-6 times a week and 6= every day). The answers concerning participation in sport club training and in competitive sport were coded from 1 to 3, 1) representing inactivity or very low activity, 2) moderately intensive or frequent activity, and 3) frequent or vigorous activity. Participation in a school sport club was coded as 1 (no) or 2 (yes). After coding, a sum index for physical activity was calculated by summing the variables. This index comprised four variables with a total score ranging from 3 to 14. The items were identical at both assessment points except for the item of participation in different sports, where the participants answered the question " What type of sports do you participate in" by marking yes / no against each item in a list of different sports. To include more recent sports, the list of sports was slightly modified for 2001.The original questionnaire is presented in appendix 8.

In follow-up 2001, the physical activity questionnaire consisted of questions concerning the frequency of physical activity, which was elicited by the question "How often do you participate in leisure-time physical activity". A 7-point re-

sponse scale was used which was subsequently recoded from 1 to 3, 1) representing leisure-time physical activity at most 3 times a month, 2) 1-4 times a week and 3) 5-7 times a week. Other questions concerned the average duration of a leisure-time physical activity session (0=not at all, 1=at most 20 minutes, 2=20-60 minutes and 3=60 minutes or longer), participation in competitive sport events (0=not at all, 1=at most sport- club level and 2=regional / national / international level) and participation in organized leisure-time physical activity (0=not at all, 1=at most 3 times a month, 2=1-2 times a week, 3=3-7 times a week) and intensity of participation (1=not quite breathlessness, 2=somewhat breathless, 3=heavily breathless). In 2001 the physical activity index comprised 5 variables with a total score ranging from 1 to 14. The follow-up questionnaire is presented in appendix 9 (questions number 38, 39, 43, 41, 42).

In order to analyze the risk levels of high, average and low adolescence physical activity and fitness categories for adult physical inactivity or low self-estimated fitness, subjects were divided into three categories according to their level of physical activity and fitness in 1976, and their level of physical activity in 2001. Among males, the lowest physical activity and fitness categories comprised 21% of subjects as compared to 26% for physical activity and 36% for self-estimated fitness in 2001. The highest category in physical activity and fitness comprised 26% of subjects as compared to 21% for physical activity and 36% for self-estimated fitness in 2001. Among females, 24% belonged to the lowest and 24% to the highest category in the physical activity and fitness indices in 1976 as compared to 16% and 21% in the physical activity index and 31% and 36% in self-estimated fitness index in 2001.

4.2.4 Validity and reliability of the measurements

In the secular trend study, in both spring 1976 and spring 2001, specially trained and educated teams carried out measurements of fitness in selected schools using identical methodology (Nupponen 1981). The tests conformed to the international standards for assessments, and have been described in detail earlier (Larson 1974).The tests had been shown to have good validity and satisfactory reliability (Safrit 1990). Validity coefficients for aerobic fitness test have varied between 0.65 and 0.88 (Safrit 1990). In previous studies intra-tester reliability for long distance running has varied between 0.65 and 0.94 and for muscular fitness tests between 0.57 and 0.98 (Simons *et al.* 1982; Safrit 1990) (table 3). In this study the intra-tester reliability based on a repeat test conducted 2 weeks later varied between 0.61 and 0.92 in 1976 (n=25) and 0.53 and 0.99 in 2001 (n=36). The reliability (Cronbach's α) for the muscular fitness index was 0.77 in boys and 0.78 in girls in 1976; in 2001 the corresponding figures were 0.76 and 0.80.

Table 3 Test-retest coefficients of physical fitness items in previous studies (Simons *et al.* 1982; Nupponen 1981 and in the present study.

Test-item	Test-retest coefficients in previous studies	Test-retest coefficients in 2001 boys (n=18) / girls (n=18)
Long-distance run	0.65-0.94	0.81 / 0.54
Sit-up	0.57-0.94	0.69 / 0.49
Pull-up	0.79-0.96	0.99 / -
Flexed arm hang	0.74-0.91	-/0.96
4 x 10 m shuttle run	0.63-0.91	0.53 / 0.83
Standing broad jump	0.80-0.96	0.92 /0.88

The fitness test items can be defined simply as performances which do not assess only one component of physical fitness only. The items associate with each other, and the interrelationships between them are indicated by correlation coefficients (tables 4 and 5). In the present study, the highest correlation coefficients were found in males between the standing broad jump and 4 x 10 m shuttle run at both assessment points. In females the highest correlation was between the standing broad jump and the 4 x 10 m shuttle run in 1976 and between long-distance running and the 4 x 10 m shuttle run in 2001. In general, the standing broad jump was the most consistent item. The correlation coefficients between the standing broad jump and all the other items were over 0.40, excluding the long-distance run in 1976.

In the follow-up study, the validity of the physical activity measurements was investigated in adolescence by describing the correlations between the physical activity index, aerobic fitness index and muscular fitness index (table 10). The internal consistency coefficients (Cronbach's α), used as an indicator of the reliability of the physical activity index, were 0.68 in 1976 and 0.76 in 2001 among males, and 0.58 in 1976 and 0.68 in 2001 among females. In addition, the internal consistency coefficients of the physical fitness index (FI) were 0.77 among males and 0.79 among females.

Table 4 The inter-correlation coefficients among males in 1976 and in 2001.

Test-item	Pull-up	4 x 10 m shuttle run	Sit-up	Long-distance run
Standing broad jump				
1976	0.51	-0.56	0.48	-0.26
2001	0.56	-0.68	0.56	-0.63
Pull-up				
1976		-0.29	0.34	-0.38
2001		-0.34	0.42	-0.45
4 x 10 m shuttle run				
1976			-0.47	0.16
2001			-0.56	0.62
Sit-up				
1976				-0.28
2001				-0.53

Table 5 The inter-correlation coefficients among females in 1976 and in 2001.

Test-item	Flexed arm hang	4 x 10 m shuttle run	Sit-up	Long-distance run
Standing broad jump				
1976	0.45	-0.62	0.45	-0.36
2001	0.43	-0.60	0.52	-0.46
Flexed arm hang				
1976		-0.39	0.35	-0.36
2001		-0.38	0.37	-0.38
4 x 10 m shuttle run				
1976			-0.39	0.38
2001			-0.53	0.62
Sit-up				
1976				-0.39
2001				-0.60

In the follow-up the index of self-estimated physical fitness (SEFI) was calculated by summing the scores for question 1 (self-estimated endurance, speed, strength and flexibility) and question 2 (self-estimated performances in varied terrain) (appendix 6, questions 37, 49). The internal consistency (Chronbach's α) of question 1 was 0.77 among males and 0.83 among females. In previous studies it has varied from 0.75 and 0.82 (Lintunen 1995). The internal consistency of question 2 on self-estimated performance was 0.88 in males and 0.82 in females, and of the index of self-estimated physical fitness 0.87 for both sexes. For 64 participants the fitness tests included a bicycle ergometer test, ergojump test (counter-movement and jumping in 15 s), sit-up test, hand-grip test and sit-and-reach test (Mikkelsson *et al.* 2005). An age- and gender-adjusted index of meas-

ured physical fitness was calculated and Spearman's correlation coefficient between the overall measured and self-estimated fitness index was 0.56 ($p<0.001$). The correlation coefficient between measured and self-estimated fitness items varied from 0.13 (handgrip test in men) to 0.57 (sit-and-reach test in men) (Mikkelsson *et al.* 2005).

4.2.5 Differences in physical fitness characteristics, BMI and physical activity index between responders and non-responders at follow-up

The differences in the adolescence fitness test scores, body mass index and physical activity index between those who responded to the follow-up questionnaire compared to those who did not respond were examined by age-adjusted univariate analysis of variance (ANCOVA) (table 6). The results showed statistically significant better scores in the fitness indices for responders compared to non-responders in both the aerobic fitness index (AFI) and muscular fitness index (MFI) among both males and females. In addition, differences were found in the physical activity index (PAI) and BMI in females but not in males.

Table 6 The aerobic fitness index (AFI), muscular fitness index (MFI), physical activity index (PAI) and body mass index (BMI) in the follow-up study in the responders and non-responders.

Variables	Males			Females		
	Responders	Non-responders	p-value[a]	Responders	Non-responders	p-value[a]
AFI	0.1 (1.0) n=407	-0.1 (1.0) n=244	0.020	0.1 (0.9) n=386	-0.2 (1.1) n=200	0.007
MFI	0.2 (2.9) n=509	-0.3 (3.2) n=332	0.025	0.3 (3.0) n=603	-0.4 (3.1) n=308	0.002
PAI	9.1 (2.3) n=593	8.7 (2.4) n=376	0.058	8.5 (1.9) n=708	8.2 (1.9) n=392	0.001
BMI	19.4 (2.3) n=522	19.7 (3.2) n=334	0.257	19.8 (2.5) n=611	20.3 (2.6) n=318	0.001

[a]) p-value for the difference between responders and non-responders.

4.3 Statistical analyses

In the secular trend data, the fitness test results are expressed as means and standard deviations (SD) and as age-and gender- specific z-scores. An index of aerobic fitness (AFI) was calculated by transferring the running test results to age-standardized z-points separately for boys and girls. In addition, an index of muscular fitness (MFI) was calculated as the sum of the age- and gender-specific z-scores of the four fitness tests (articles I and II).

Student's t-test and Mann-Whitney's U-test (I, II) were used to compare differences in aerobic and muscular fitness between the measurement points in both boys and girls. Mean values, 95% confidence intervals (95% CI) and the standardized differences (Cohen's *d*) were calculated. Changes in the distributions of the populations were analysed by comparing four percentile points, 10% (the worst), 25%, 75% and 90% (the best), for the same gender-age groups in the 1976 data with the corresponding percentiles in the 2001 data.

The association between age, leisure-time physical activity, BMI and aerobic/muscular fitness was examined at both measurement points. ANCOVA (I), linear regression (I) and complex samples general linear model with Huber-White estimator (II) were applied in testing the differences and changes in the explanation rates of fitness between the physical activity and BMI categories at both assessment points.

In the follow-up data the association between fitness and physical activity in adolescence and adult levels of physical activity or self-estimated fitness were examined by Spearman's rank order correlation and partial correlation, controlling for age (articles III, IV). Different categories of physical activity and fitness in ado-

lescence for adult physical inactivity and low self-estimated fitness were analysed using multinominal logistic regression (III, IV). The odds ratios and their 95% confidence intervals (95% CI) were calculated. In all the analyses, males and females were analyzed separately. All the statistical tests were performed by SPSS version -15.0 (I, II, III) and -18.0 (IV) (SPSS, Chicago, Illinois, USA).

5 RESULTS

5.1 Secular trends and distributional changes in aerobic and muscular fitness

5.1.1 Aerobic fitness

Mean 2 000 m running test time for boys in 1976 was 559 sec (95% confidence interval (CI), 548 to 5 70 sec) and in 2001 6 15 sec (95% CI, 600 t o 630 sec). Mean 1 500 m running test time for girls in 1976 was 494 s ec (95% CI, 486 to 503 sec) and in 2001 523 sec (95% CI, 510 to 535 sec). The mean difference between 1976 and 20 01 among bo ys was 56 sec (increase 10%, p<0.001) and among girls 29 sec (increase 6%; p=0.01) (figure 4).

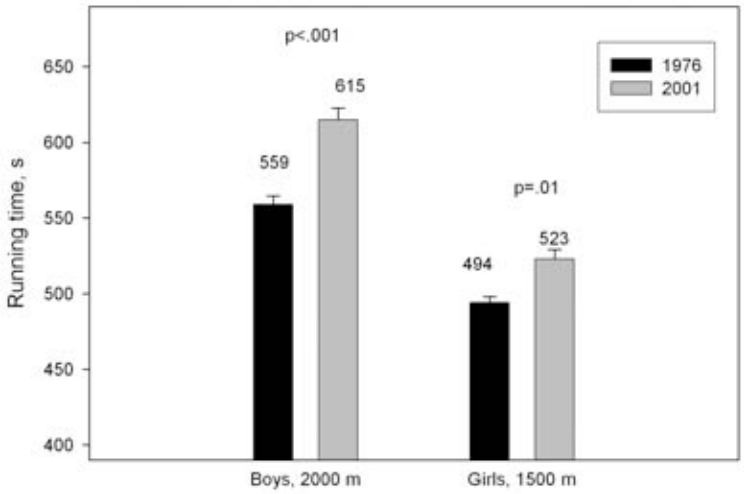


Figure 4 Running time in boys and girls in 1976 and in 2001. Age-adjusted p-values for difference between 1976 and 2001 are shown.

Figure 5 shows the distributional changes in the long distance running test. Comparison of the different percentile categories of the distributions between 1976 and 2001 shows that, both the boys and girls in 1976 were better in all the percentile categories.

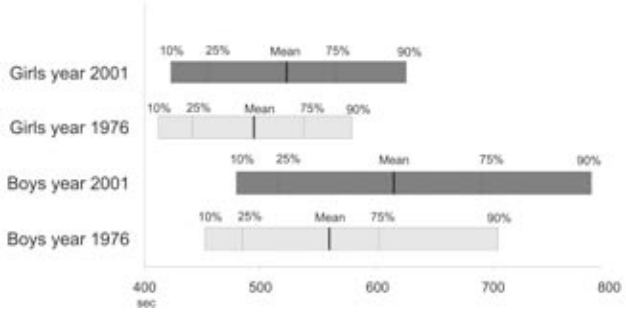


Figure 5 Distributions of running time in aerobic fitness test in 1976 and 2001 (2 000 m run for boys and 1 500 m run for girls).

5.1.2 Muscular fitness

The muscular fitness index (MFI), improved during the study period (figure 6). The mean MFI increased for boys by 0.77 points (95% CI 0.26 to 1.74, p=0.008) and for girls by 1.01 points (95% CI 0.40 to 2.1, p= 0.004) between 1976 and 2001.

Sit-ups improved significantly over time in both sexes (figure 6 and table 7). The boys averaged 19.8 sit-ups / 30 sec in 1976 as compared to 22.5 in 2001 (improvement 13.6%, p<0.001). Similarly, in girls the number of sit-ups increased from 16.5 to 18.0 (improvement 9.1%, p<0.001).

Upper body muscular fitness for boys was measured by the **pull-up test** and for girls by **the flexed arm hang test** (figure 6 and table 7). In 1976, the boys averaged 5.1 pull-ups whereas in 2001 this number had fallen to 4.2 (decrease of 21.2%, BMI-adjusted p= 0.014). The results of the girls' flexed arm hang test showed no difference between 1976 and 2001.

The results for the **agility 4x10 m shuttle run** had also improved over time (figure 6 and table 7) . The mean running time improved by 0.5 sec in boys (4.7%, p<0.001) and by 0.3 sec in girls (2.3%, p<0.001).

There were no statistically significant changes in the **standing broad jump** results among boys over the period (figure 6 and table 7). In girls the results indicated a mild tendency towards higher scores from 1976 to 2001 (1.9%, p=0.034).

Table 7 Means, (standard deviations) and p-values for the differences between 1976 and 2001 in the different test items for muscular fitness.

Test item	Boys			Girls		
	1976	2001	p-value	1976	2001	p-value
Sit-ups (reps. / 30 s)	19.8 (4.2)	22.5 (5.0)	<0.001	16.5 (3.7)	18.0 (5.0)	<0.001
4 x 10 m shuttle run (s)	12.0 (1.0)	11.4 (1.2)	<0.001	12.8 (1.0)	12.5 (1.1)	<0.001
Pull-up (reps.)	5.1 (3.6)	4.2 (4.3)	<0.001			
Flexed arm hang (s)				13.2 (10.3)	13.4 (12.5)	0.774
Standing broad jump (cm)	207.1 (27.4)	209.4 (29.2)	0.3	173.3 (21.4)	176.6 (23.0)	0.034

Figure 6 show the distributional changes in the different muscular fitness tests. The Levene's test for equality of variances showed that the variances increased between 1976 and 2001 ($p<0.05$), except for the standing broad jump test. The strongest distributional changes were found in the agility shuttle run, sit-up and, in boys, pull-up tests. The distribution of the tests showed differences over time, particularly at the highest fitness level, with smaller changes in girls than in boys. The boys in 2001 were better in the shuttle run and sit-up tests in all the percentile categories compared to boys in 1976, except in the shuttle run in the lowest percentile category where the result was unchanged ($p=0.15$). In the pull-up test in 2001, 25.4% of boys scored 0, although at the higher percentile levels the scores were better than in 1976. As in the boys, the girls performed better in the shuttle run and sit-up tests in 2001, although in the lowest percentile category no significant difference was observed between 1976 and 2001.

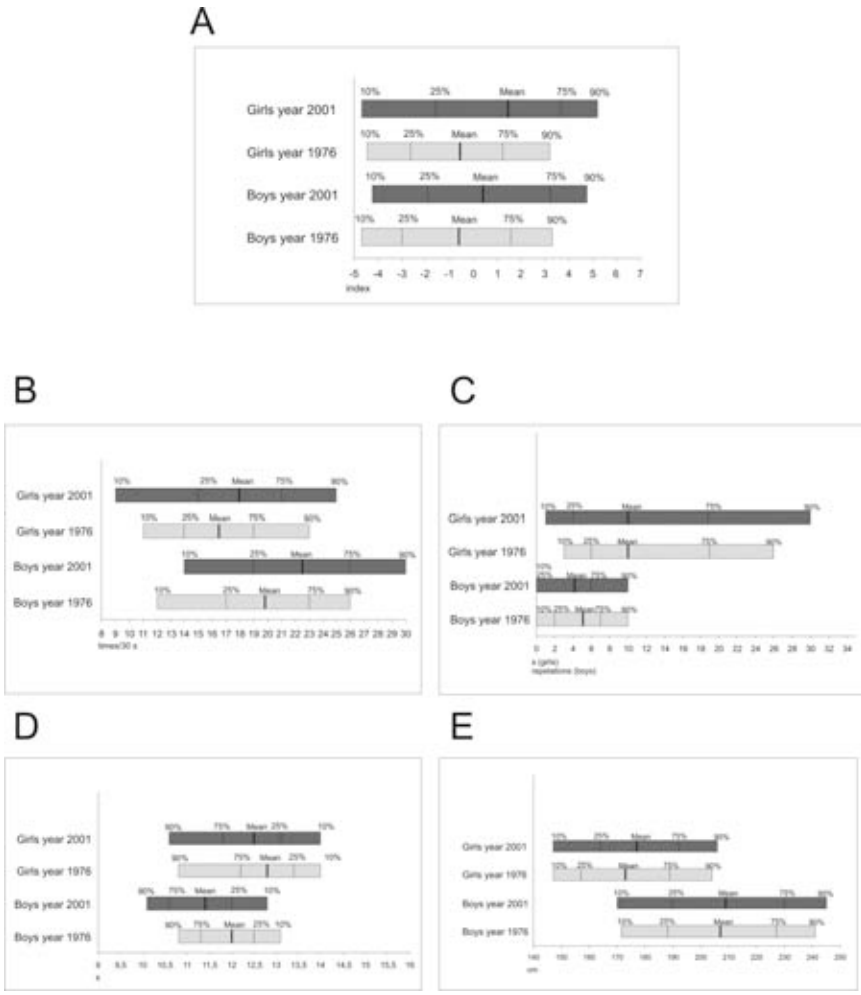


Figure 6 Distributions and secular trends in the muscular fitness index (A) and its components, sit-up (B), pull-up / flexed arm hang (C), shuttle run (D) and standing broad jump (E).

5.2 Leisure-time physical activity and body mass index (BMI) as determinants of physical fitness

5.2.1 Leisure-time physical activity and BMI as determinants of aerobic fitness

Figure 7 shows that aerobic fitness was lower in 2001 than in 1976 in all the LTPA groups among boys. The standardized difference *(d)* varied from 0.37 to 0.60 (small / medium) over the time. Among girls, differences were found between the two lowest LTPA groups with a large effect-size (d=0.73) reported for

differences between the lowest LTPA groups; however, the girls reporting daily physical activity had similar fitness levels in both 1976 and 2001.

According to the BMI international cut-offs (Cole *et al.* 2000), 14 (6%) of the boys were overweight or obese in 1976 and 37 (12%) in 2001. Among the girls 7 (4%) were overweight or obese in 1976 and 30 (12%) in 2001. Obese or overweight subjects had lower aerobic fitness compared to normal weight subjects in both 1976 and 2001 among boys (in 1976 p=0.004 and in 2001 p<0.001) and among girls in 2001 (p<0.001). After adjustment for age and BMI, no statistically significant difference emerged in the aerobic fitness of obese/overweight boys between 1976 and 2001, while overweight/obese girls showed lower aerobic fitness in 2001 than in 1976 (p=0.036).

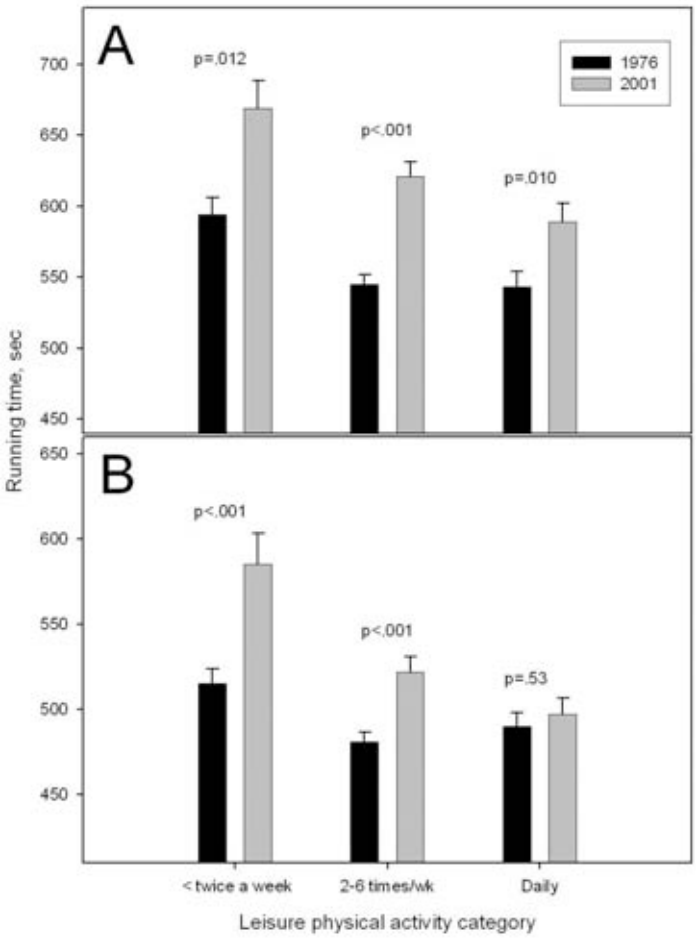


Figure 7 Running time by physical activity category in 1976 and 2001 in boys (A) and girls (B). Age-adjusted p-values for difference between 1976 and 2001 are shown.

Table 8 shows the results of the age-adjusted linear regression analysis for the individual determinants of aerobic fitness and the results of the linear regression analysis in which age, BMI and frequency of LTPA and sport club participation were included in the model as explanatory variables. Among boys, the cumulative R^2 of this model was 0.082 in 1976 and 0.230 in 2001. For girls the R^2 of the model was 0.082 in 1976 was and 0.335 in 2001. Participation in leisure-time physical activity was the only significant determinant in both boys and girls in 1976. In contrast, excluding age, the values of all the investigated variables were significant in both sexes in 2001.

Table 8 Determinants of aerobic fitness index for boys and girls in 1976 and 2001.

Determinant	Values for individual determinants[a]			Cumulative model[b]	
	estimate	95% CI	R^2	R^2	p-value
Year 1976 boys (n=211)					
Age	-0.11	-0.17 to 0.02	.008	.008	0.10
BMI	-0.13	-0.12 to 0.01	.018	.018	0.081
Leisure-time PA	0.26	0.16 to 0.53	.064	.070	<0.001
Sport club participation	0.20	0.08 to 0.42	.042	.082	0.059
Year 2001 boys (n=292)					
Age	0.10	-0.01 to 0.18	.007	.007	0.078
BMI	-0.36	-0.15 to -0.08	.127	.127	<0.001
Leisure-time PA	0.23	0.19 to 0.55	.058	.179	<0.001
Sport club participation	0.30	0.20 to 0.44	.096	.230	<0.001
Year 1976 girls (n=166)					
Age	0.08	-0.05 to 0.16	.000	.000	0.33
BMI	-0.10	-0.10 to 0.03	.002	.002	0.23
Leisure-time PA	0.26	0.14 to 0.52	.062	.077	<0.001
Sport club participation	0.16	0.01 to 0.42	.020	.082	0.18
Year 2001 girls (n=244)					
Age	-0.06	-0.15 to 0.06	.000	.000	0.39
BMI	-0.42	-0.18 to -0.10	.165	.165	<0.001
Leisure-time PA	0.30	0.29 to 0.67	.087	.210	<0.001
Sport club participation	0.42	0.37 to 0.65	.168	.335	<0.001

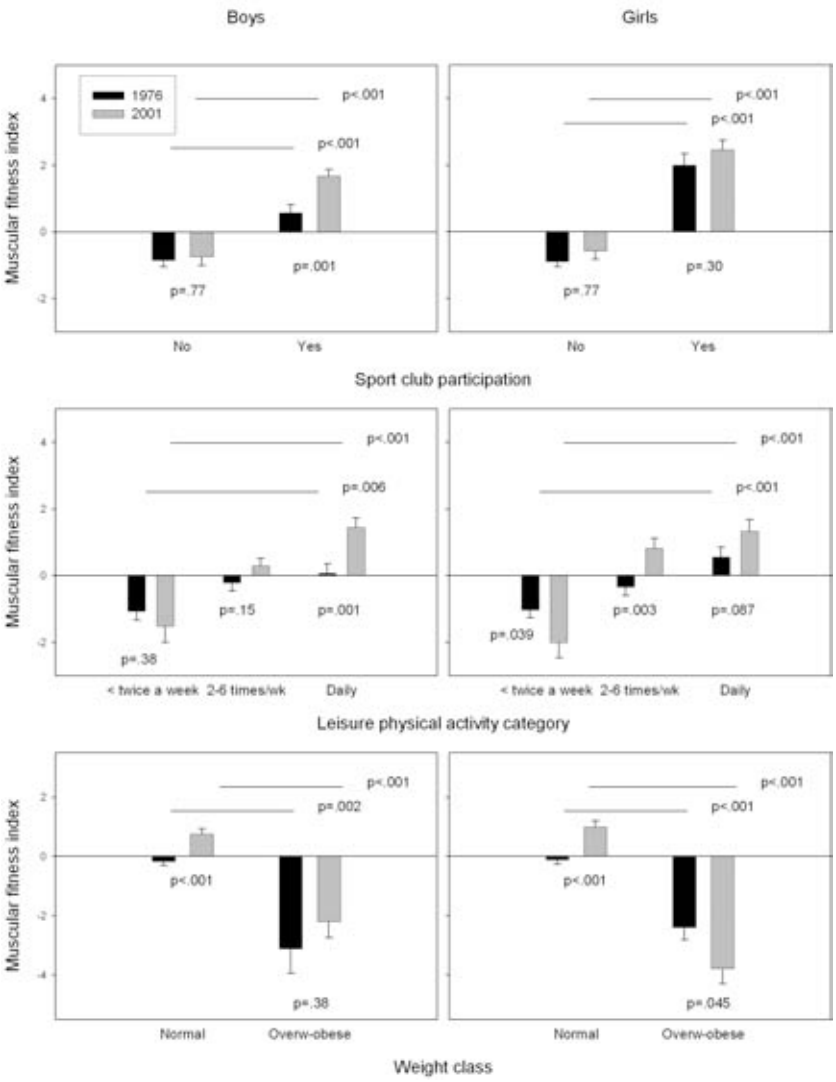
[a]) By linear regression analysis, values for determinants other than age are from models in which age has been entered first.

[b]) By linear regression analysis, R^2 and p-values are from a fixed cumulative model.

5.2.2 Leisure-time physical activity and BMI as determinants of muscular fitness

Physically active adolescents had a higher MFI than those who were physically inactive in both 1976 and 2001 (figure 8). In 2001 boys who participated daily in leisure-time physical activity and participated in organized sport had higher MFI compared to their counterparts in 1976 ($p<0.001$). However, there were no significant differences in the lower activity groups. In contrast, among girls there were no significant differences between 1976 and 2001 in MFI determined by daily participation in leisure-time physical activity and participation in organized sport. However, among the girls, those who participated in leisure-time physical activity 2-6 times/week ($p=0.003$) had higher MFI in 2001 than their counterparts in 1976, whereas MFI was lower among those who participated <2 times / week ($p=0.039$).

In addition, the results also clearly show an association between overweight and poorer performance in the muscular fitness tests. In both sexes, MFI was significantly lower among overweight / obese than normal weight participants in both study years: in girls in 1976 $p< 0.001$ and in 2001 $p< 0.001$; in boys in 1976 $p=0.002$ and in 2001 $p<0.001$. Among the normal weight participants mean MFI was higher in 2001 than in 1976 in both girls ($p<0.001$) and boys ($p<0.001$).



p-values for difference between 1976 and 2001 are shown under bars and p-values for difference between different categories in 1976 (under line) and 2001 (up line) above bars.

Figure 8 Muscular fitness index by sport club participation, leisure-time physical activity and BMI categories in 1976 and 2001 in boys and girls.

Table 9 shows the results of the multivariate analysis in which BMI, LTPA and sport club participation were included in the model as explanatory variables of muscular fitness. Among boys the cumulative R^2 of this model was 0.099 in 1976 and 0.237 in 2001. For girls the R^2 of the model was 0.249 in 1976 and 0.399 in 2001. Sport club participation was the strongest determinant in the cumulative regression model, the R^2 for sport club participation as an individual determinant

increasing from 0.079 to 0.158 in boys and from 0.165 to 0.200 in girls. The R^2 for BMI and LTPA separately also increased over time. In boys the R^2 for BMI increased from 0.017 to 0.068 and in girls from 0.067 to 0.214. The R^2 for LTPA increased from 0.025 to 0.056 in boys and from 0.043 to 0.102 in girls.

Table 9 Determinants of muscular fitness index for boys and girls in 1976 and 2001.

Determinant	Values for individual determinants[a]			Cumulative model[b]	
	estimate	95% CI	R^2	R^2	p-value
Year 1976 boys (n=310)					
Age	-0.18	-0.59 to 0.23	.005		
Sport club participation	0.97	0.59 to 1.34	.079		<0.001
BMI	-0.13	-0.27 to 0.02	.017		0.126
Leisure-time PA	0.32	0.10 to 0.54	.025	.099	0.128
Year 2001 boys (n=300)					
Age	0.17	-0.41 to 0.69	.002		
Sport club participation	1.29	0.85 to 1.73	.158		<0.001
BMI	-0.28	-0.42 to -0.13	.068		<0.001
Leisure-time PA	0.63	0.19 to 1.07	.056	.237	0.119
Year 1976 girls (n=330)					
Age	-0.03	-0.48 to 0.42	.000		
Sport club participation	1.75	1.20 to 2.29	.165		<0.001
BMI	-0.30	-0.41 to -0.18	.067		<0.001
Leisure-time PA	0.40	0.20 to 0.59	.043	.249	0.004
Year 2001 girls (n=264)					
Age	-0.06	-0.98 to 0.86	.000		
Sport club participation	1.68	1.23 to 2.14	.200		<0.001
BMI	-0.49	-0.62 to -0.36	.214		<0.001
Leisure-time PA	1.05	0.58 to 1.52	.102	.399	0.001

[a]) According to general linear model (Huber-White estimates), values for other determinants in model where age has been entered first.

[b]) R^2 and p-values obtained from a fixed cumulative general linear model.

5.3 Leisure-time physical activity and fitness in adolescence as predictors of leisure-time physical activity in adulthood

Among males at age 12-18, the percentages of those who participated in leisure-time physical activity daily, 1-6 times a week and less than once a week were 26.9%, 59.4% and 13.7%, respectively; among females the corresponding percentages were 29.1%, 60.3% and 10.6%. At age 37-43 the percentage of males

who participated in leisure-time physical activity daily was 3.6%, 1-6 times a week 68.7% and less than once a week 27.7%; among females the corresponding percentages were 7.5%, 74.7% and 17.8%. At age 12-18 the percentage of males who participated in a sports club was 38.0% and that of females 20.8%. Twenty-five years later the percentage of males who were regular participants in a sport club was 20.8% and that of females 38.0% (table 2).

5.3.1 Cross-sectional and longitudinal associations between physical fitness and leisure-time physical activity

Table 10 shows the Spearman's correlation coefficients between the fitness and physical activity indices in adolescence and the correlation coefficients from adolescence to adulthood in the two age groups. There was a significant correlation between the aerobic fitness index, muscular fitness index and physical activity index in adolescence in 1976. The correlation coefficients were low or moderate and ranged from 0.20 to 0.48. Among males, the correlation coefficient between aerobic fitness index in adolescence and adult physical activity index was 0.19 ($p<0.05$) in the older age group but between the muscular fitness index and adult physical activity it was non-significant. Among females, there was no significant correlation between the baseline fitness indices and adult physical activity.

5.3.2 Longitudinal association of leisure time physical activity

Among males age-adjusted physical activity showed a small but statistically significant correlation with adult physical activity in both the younger ($r=0.14$, $p<0.05$) and older age-groups ($r=0.31$, $p<0.001$), while among females a significant but small association between physical activity from age 16-18 to age 41-43 ($r=0.17$, $p<0.05$) was observed (table 10). In general, the longitudinal correlation coefficients were higher in the older age group and the associations from adolescence to adulthood were stronger for the physical activity index than for the fitness indices.

Table 10 Correlation coefficients between the aerobic fitness index (AFI), muscular fitness index (MFI) and physical activity index (PAI 1976 and PAI 2001) in adolescence and from adolescence to adulthood in two age groups (age 12-15 and 16-18).

Variable	12-15 years			16-18 years		
	AFI 1976	PAI 1976	PAI 2001	AFI 1976	PAI 1976	PAI 2001
MFI 1976						
Males	0.48***	0.25**	0.10	0.28**	0.40***	0.14
Females	0.48***	0.37***	0.04	0.36**	0.20**	0.10
AFI 1976						
Males		0.31***	0.11		0.44***	0.19*
Females		0.43***	0.06		0.32***	0.01
PAI 1976						
Males			0.14*			0.31***
Females			0.05			0.17*

*p<0.05; ** p<0.01; *** p<0.001

5.3.3 Risk for adult leisure-time physical inactivity in the various adolescence physical fitness and leisure-time physical activity groups

Table 11 shows the results of the regression analyses for adult physical inactivity at age 37-43. The results show that among both sexes low level of physical activity in adolescence predicted higher risk for adult inactivity. The odds ratio (OR) for being inactive as an adult for those who were physically very active in adolescence compared to those who were inactive in adolescence was 0.13 (95% CI 0.06-0.31) for males and 0.28 (95% CI 0.13-0.59) for females. In addition, the OR for adult inactivity was 0.24 (95% CI 0.07-0.81) among males in the highest fitness group compared to those in the lowest fitness group in adolescence; among females this odds ratio was not significant.

Table 11 Odds ratios (OR) for physical inactivity in adulthood according to the physical activity (PAI) and physical fitness (FI) categories in adolescence (adjusted for age).

	Males at age 37-43			Females at age 37-43		
	OR[a]	95% CI	p-value	OR[a]	95% CI	p-value
PAI at age 12-18		(n=616)			(n=718)	
		Inactive vs Very active			Inactive vs Very active	
Low activity	1.00			1.00		
Average activity	0.33	0.15-0.73	0.006	0.76	0.42-1.40	0.379
High activity	0.13	0.06-0.31	<0.001	0.28	0.13-0.59	0.001
		Inactive vs Active			Inactive vs Active	
Low activity	1.00			1.00		
Average activity	0.59	0.37-0.93	0.024	0.73	0.45-1.18	0.198
High activity	0.55	0.32-0.97	0.037	0.39	0.20-0.74	0.004
FI at age 12-18		(n=245)			(n=219)	
		Inactive vs Very active			Inactive vs Very active	
Low fitness	1.00			1.00		
Average fitness	0.55	0.19-1.61	0.274	0.96	0.34-2.70	0.935
High fitness	0.24	0.07-0.81	0.020	0.79	0.23-2.73	0.703
		Inactive vs Active			Inactive vs Active	
Low fitness	1.00			1.00		
Average fitness	0.70	0.34-1.44	0.333	0.67	0.32-1.53	0.430
High fitness	0.54	0.22-1.31	0.173	0.64	0.33-2.04	0.374

[a)] Odds ratios from the multinominal regression analyses.

5.4 Leisure-time physical activity and fitness in adolescence as predictors of self-estimated fitness in adulthood

5.4.1 Self-estimated fitness as an adult

Scores for participants' self-estimation of their fitness level and performances are presented in table 12 and 13. The majority of the participants evaluated their fitness levels as at least average for every fitness characteristic. For endurance, 37.8% of males and 32.3% of females estimated their fitness to be above average, while for flexibility, 38.1% of males and 36.6% of females evaluated their fitness as below average compared to other persons of the same age and sex. In general, males reported higher self-estimated fitness than females (t= 9.7, p<0.001).

Table 12 Distributions (%) of answers of males (n=613) and females (n=705) to items on self-estimated physical fitness at age 37-43.

Estimated fitness qualities	Level of self-estimated fitness				
	Clearly below average level	Below average level	Average level	Above average level	Clearly above average level
Endurance					
Males	2.9	15.7	43.6	28.2	9.6
Females	4.8	18.0	44.8	27.5	4.8
Speed					
Males	3.3	19.2	50.2	21.9	5.4
Females	7.0	27.0	48.1	16.5	1.6
Strength					
Males	1.8	14.2	49.3	26.6	8.2
Females	5.1	17.2	48.9	22.0	6.8
Flexibility					
Males	10.3	27.6	41.6	15.7	4.9
Females	9.8	26.8	41.1	18.0	4.3

Table 13 Distributions (%) of answers of males (n=613) and females (n=705) to items on self-estimated distances to be able to perform at age 37-43.

Estimated fitness qualities	Self-estimated distance			
Running continuously	Less than500 m	500-1000 m	1-5 km	Over 5 km
Males	7.8	20.2	41.6	30.3
Females	28.2	35.7	26.8	9.2
Cycling continuously	Less than 10 km	10-20 km	21-50 km	Over 50 km
Males	6.2	23.5	41.9	28.4
Females	11.5	45.8	34.9	7.8
Skiing continuously	Less than 5 km	5-10 km	11-30 km	Over 30 km
Males	14.1	30.6	35.8	19.6
Females	22.8	47.0	26.7	3.5
Walking continuously	Less than 5 km	5-10 km	11-20 km	Over 20 km
Males	5.7	24.5	33.8	35.9
Females	7.9	38.2	37.0	16.9

5.4.2 Leisure-time physical activity and fitness as predictors of self-estimated fitness

Spearman's correlation coefficients between the self-estimated fitness sum index with its items in adulthood in 2001 and the PAI and fitness indices (AFI and MFI) in adolescence in 1976 are shown in table 14. There was a significant correlation between the SEFI in 2001 and PAI in 1976 among both males (0.25) and females (0.24). The correlation coefficients between the self-estimated fitness items and

PAI ranged from 0.13 to 0.18 among males and from 0.12 to 0.21 among females. In addition, statistically significant associations between the level of fitness indices and adult SEFI were found in both sexes. The coefficients between the self-estimated fitness items (endurance, strength, speed and flexibility) as an adult and measured fitness indices in adolescence varied between 0.14 and 0.45 among males and between 0.22 and 0.34 among females.

Table 14 The correlation coefficients between the self-estimated fitness index SEFI in adulthood in 2001 and the physical activity index (PAI) and fitness indices (AFI and MFI) in adolescence in 1976.

Variables in adulthood in 2001	PAI 1976	AFI 1976	MFI 1976
SEFI			
Males	0.25***	0.24***	0.45***
Females	0.24***	0.32***	0.38***
Endurance			
Males	0.15***	0.44***	0.36***
Females	0.21**	0.36***	0.28***
Strength			
Males	0.14***	0.14**	0.37***
Females	0.19**	0.26***	0.23***
Speed			
Males	0.18***	0.22***	0.41***
Females	0.16**	0.36***	0.43***
Flexibility			
Males	0.13*	0.15**	0.34***
Females	0.18**	0.26***	0.31***

*p<0.05; ** p<0.01; *** p<0.001

Table 15 shows the results of the multinomial regression analyses for adult low self-estimated fitness at age 37-43. The results show that among both sexes low level of physical activity and fitness in adolescence associated with a higher risk for low self-estimated fitness in adulthood. The odds ratio (OR) for a low fitness estimation as an adult for those who were physically very active in adolescence compared to those who were inactive in adolescence was 0.18 for both sexes (95% CI 0.10-0.32 for males and 0.10-0.34 for females). Among males the OR for a low fitness estimation as an adult was 0.19 (95% CI 0.07-0.56**),** and among females 0.14 (95% CI 0.05-0.47) in the highest compared to lowest fitness group in adolescence.

Table 15 Odds ratios (OR) for low self-estimated physical fitness in adulthood according to the physical activity (PAI) and physical fitness (FI) categories in adolescence (adjusted for age).

	Males at age 37-43			Females at age 37-43		
	OR[a]	95% CI	p-value	OR[a]	95% CI	p-value
PAI at age 12-18	(n=613)			(n=705)		
	Low fitness vs High fitness			Low fitness vs High fitness		
Low activity	1.00			1.00		
Average activity	0.52	0.31-0.90	0.019	0.46	0.28-0.74	0.002
High activity	0.18	0.10-0.34	<0.001	0.18	0.10-0.32	<0.001
	Low fitness vs Average fitness			Low fitness vs Average fitness		
Low activity	1.00			1.00		
Average activity	0.80	0.50-1.29	0.361	0.52	0.34-0.79	0.002
High activity	0.49	0.27-0.88	0.018	0.41	0.24-0.71	0.001
FI at age 12-18	(n=209)			(n=192)		
	Low fitness vs High fitness			Low fitness vs High fitness		
Low fitness	1.00			1.00		
Average fitness	0.35	0.13-0.89	0.028	0.21	0.08-0.58	0.002
High fitness	0.19	0.07-0.56	0.003	0.14	0.05-0.47	0.001
	Low fitness vs Average fitness			Low fitness vs Average fitness		
Low fitness	1.00			1.00		
Average fitness	0.62	0.27-1.42	0.257	0.38	0.17-0.86	0.020
High fitness	0.42	0.15-1.11	0.081	0.29	0.11-0.83	0.020

6 DISCUSSION

This dissertation examined the secular trends in physical fitness and the role of leisure-time physical activity in the secular changes in fitness among Finnish adolescents, and how leisure-time physical activity and fitness in adolescence predict leisure-time physical activity and self-estimated fitness in adulthood. This study is both a secular trend and follow-up study. The baseline data collection was carried out in 1976. In 2001, 25 years later, new cross-sectional and follow-up data were collected. This research comprises five main components. First and second, the trends and distributional changes in aerobic and muscular fitness between 1976 and 2001 were examined among Finnish adolescents. Third, the role of leisure-time physical activity and body mass index (BMI) in the secular changes in physical fitness were studied. The fourth and fifth components concern the follow-up data and are predictive studies. These studies investigated to what extent leisure-time physical activity and physical fitness in adolescence predict leisure-time physical activity and self-estimated fitness in adulthood.

6.1 Secular changes in physical fitness

One of the main findings of this study showed that, compared with the 1976 sample, boys and girls in 2001 had lower aerobic fitness and slightly higher muscular fitness. Secondly, it can be concluded that polarization increased both in aerobic and muscular fitness between 1976 and 2001.

Results showed that mean running time increased among boys by 56 s (10%) and among girls by 29 s (6%) from 1976 to 2001. The difference in mean distance-running speed among boys was 0.33 m/s and among girls 0.17 m/s. This indicates that on average, a boy in 2001 would finish about 180 m behind his average 1976 counterpart over the 2 000 m distance. In girls the corresponding difference in the 1 500 m run was 83 m. After BMI and leisure-time physical activity adjustment, a

significant secular decline was found among both boys (p= 0.011) and girls (p=0.017).

The decline in aerobic fitness performance is in accordance with the findings of a number of shorter-term studies from other countries on secular trends in aerobic fitness performance (Tomkinson *et al.* 2003; Wedderkopp *et al.* 2004; Dyrstad *et al.* 2011) Tomkinson and colleagues (2003) investigated 20m shuttle run performance in children aged 6-19 years from 11 developed countries during the period 1981-2000 and found a decrease in aerobic performance of 0.43% per year. In this study the time taken to run increased on average from 1976 to 2001 by 0.40% per year in boys and 0.24% in girls. However, it is difficult to know the exact time-related patterns of change. It is possible that, due to the more sedentary lifestyle found among adolescents, the change in fitness over the last decade has been more rapid than that in the first decade (Santtila *et al.* 2006). In the present study the distributions showed a decline in all four percentile categories, with the largest change in the poorest aerobic fitness category in both boys and girls. Despite these results, a worldwide analysis of 109 studies from 37 countries showed that the best performing children and adolescents in aerobic performance were in the Northern European countries, including Finland (Olds *et al.* 2006).

The results also indicated secular changes in the health-related muscular fitness of Finnish adolescents between 1976 and 2001. The finding was that compared with the 1976 sample, the 13- to 16-year-old adolescents in 2001 had a slightly higher muscular fitness index. The results showed a positive trend, in particular in the agility shuttle run and sit-up tests in both boys and girls. In contrast, among boys upper body strength was lower while there was no change in performance in the standing broad jump over time in boys and only a slight positive trend in girls.

These results largely concur with the findings of some previous studies in which the secular trend in muscular strength has remained either unchanged or has slightly improved (Tomkinson 2007; Volbekienė & Griciūtė 2007; Albon *et al.* 2010). Compared with other European countries, there were both similarities and differences in the secular trend in the sit-up test. A slight increase in sit-up scores has been found among Lithuanian youth but a decrease among Swedish youth (Westerståhl *et al.* 2003b; Volbekienė & Griciūtė 2007). Przeweda (2000) reported a 0.17% improvement per annum during a 10-year period in the 4 x 10 m agility shuttle run among 7- to 19-year-old Polish youth. In this data the improvement was 0.19 % among boys and 0.09% among girls. In the sit-up test the secular changes were rather large: 0.54% per annum among boys and 0.36% among girls. In his review on strength and speed tests Tomkinson (2007) concluded that relative to the secular changes found in aerobic fitness test performance, the changes in anaerobic performance are considerably smaller.

Evaluation of the changes in the distributions of the results showed an increase in polarization in both aerobic and muscular fitness between 1976 and 2001. This means that normal distributions have become flatter with longer tails, the left tail showing that the subjects with low fitness have lower physical fitness, and, the right tail that the subjects with high physical fitness have higher physical fitness than earlier. This is also in accordance with previous studies (Wedderkopp *et al.* 2004; Møller *et al.* 2007; Albon *et al.* 2010). Due to the increased polarization in physical fitness, more attention should be paid to adolescents' health-related fitness, e.g to prevent metabolic and musculoskeletal disorders among overweight and inactive adolescents. Increasing physical activity seems to be an important means toward improving fitness and preventing these disorders (Blair & Church 2004).

6.2 The role of investigated determinants in the secular changes of physical fitness

The present study indicated that participation in leisure-time physical activity had a positive association with aerobic and muscular fitness in both 1976 and 2001. Adolescents who were physically active had better fitness indices than adolescents who were physically inactive, and the highest fitness indices were found in the group of adolescents who reported daily participation in leisure-time physical activities.

In agreement with this study, the secular trend in the frequency of leisure-time physical activity among adolescents in Finland has increased during the 30 years from 1977 to 2007 in both sexes, particularly in organized sport (Laakso *et al.* 2008). This means that intensive leisure-time physical activity more often than previously means participation in organized sport. Traditionally, the share of spontaneous physical activity engaged in by adolescents has been larger in Finland than in many other countries (Telama *et al.* 2002). Notably, at the same time, aerobic fitness also decreased among the group of boys who reported daily participation in leisure-time physical activity. These results may perhaps be explained by differences over time in the types of sports engaged in, as a higher proportion of physically active children participated in endurance- type sports in 1976 than in 2001. The proportion of adolescents who participated in long distance running was 28% among boys and 35% among girls in 1976. Only 12% of boys and 14% of girls reported participating in this sport in 2001. In contrast, over one in three in both sexes participated in new sports (aerobics, snowboarding and rollerboarding). In addition, participation in strength- and gym-training increased over the study period. The proportion of those who participated in strength- and gym -training increased among boys from 23% to 28% and among girls from 6% to 18%. This accords with the view that the variety of physical activities available in organized sport is greater than before and provides more training than earlier in strength and agility (Malina 2007).

One reason for the increased polarization in physical fitness is that the number of adolescents participating in leisure-time physical activity and keeping fit has increased, while at the same time the number of very inactive adolescents has also increased and their fitness is lower than previously. Although the frequency of participation in leisure-time physical activity increased over a period of 30 years (Laakso *et al.* 2008), overall physical activity during the present 25-year study period has perhaps declined for reasons connected with societal changes and an increasingly sedentary lifestyle among, in particular, inactive adolescents (Telama *et al.* 2005b; Nelson *et al.* 2006). In addition, in 2001, the aims of physical education in schools were not perhaps as fitness-oriented as was the case in 1976 (Nupponen 1981; National Core Curriculum for Basic Education 1994; National Core Curriculum for Upper Secondary School 1994). For these reasons different ways to increase physical activity among all adolescents, including inactive ones, should be promoted, for example, by increasing the number of physical education lessons in schools so as to arouse an interest in physical activity among inactive adolescents encouraging travel to and from school by physically active ways and fostering spontaneous free sports- play (Gordon-Larsen *et al.* 2000; Andersen *et al.* 2009).

6.3 Leisure-time physical activity and fitness as predictors of leisure-time physical activity in adulthood

The present study showed statistically significant, but only low to moderate, correlations between the fitness indices and physical activity in adolescence. Previous studies have found only weak evidence for a positive relationship between habitual physical activity and health-related fitness in youth, as against a strong positive relationship in adulthood. Individuals who are more active in youth have been found to be more fit in tasks that demand good aerobic fitness, while the associations with the other components of health-related fitness have been inconsistent (Katzmarzyk *et al.* 1998; Rowlands *et al.* 2000; Malina 2001; Ara *et al.* 2004). However, the cross-sectional data in this study showed that physically active youth have both better aerobic fitness and muscular fitness than their physically inactive peers.

The follow-up results indicated that physical activity in adolescence significantly predicted adult physical activity in both males and females. The risk for adult inactivity was significantly lower for subjects who were physically very active in adolescence compared to their inactive counterparts. In males the association between the physical activity index in 1976 and the physical activity index in 2001 was significant in both the age groups of adolescents investigated. Among females a significant association was found only in the older age group of adolescents. A high level of overall physical fitness at school-age predicted reduced risk for adult physical inactivity among males. However, among females a significant association between the level of overall fitness in adolescence and adult physical activity was not observed.

A low correlation was found between the aerobic fitness index in adolescence and adult physical activity among males, while high overall physical fitness level in adolescence predicted lower risk for inactivity in adulthood. Physical fitness is to a large extent determined by heredity, and thus it could affect physical activity in all life phases. In addition, males participate more in competitive and vigorous physical activity, which may partly explain the observed gender difference (Telama 2009). Previous longitudinal studies of physical fitness from youth to adulthood are limited and generally suggest better tracking for physical fitness than for physical activity, while some data suggest that those who are fitter in youth tend to be more active in adulthood (Dennison *et al.* 1988; Barnekow-Bergkvist *et al.* 1998; Kemper *et al.* 2001; Matton *et al.* 2006). Although the results of this study showed longitudinal associations between physical fitness and physical activity only among males, in some shorter-term studies this association has also been found among females (Dennison *et al.* 1988; Barnekow-Bergkvist *et al.* 1998).

In his review, Telama (2009) points to the fact that in many previous physical activity tracking studies the follow-up times have been relatively short, shorter than in the present study, the median being nine years. Among men the stability of physical activity was significant but low or moderate, during all life phases, whereas in females the tracking correlations have been lower and in many cases non-significant (Barnekow-Bergkvist *et al.* 1998; Parsons *et al.* 2006; Scheerdrer *et al.* 2006). In the present study, in line with previous results, physical activity in adolescence correlated at a low but nonetheless significant level with physical activity in adulthood in both males and females from age 16-18 to age 41-43. The levels of the correlation coefficients were consistent with those of studies which have been carried out among study populations with a similar age range (Telama *et al.* 2005a; Parsons *et al.* 2006). However, the obtained correlations were rather weak compared to the odds ratios between the low and high physical activity categories. The results indicated that risk for adult inactivity is considerably stronger among those who are inactive in adolescence compared to their very active counterparts. The reason for this could be that the tracking in physical activity from adolescence to adulthood is not linear. Instead, the tracking in inactivity and high level activity are strong. These findings support the view that it is very important to enhance adolescents' physical activity in order for this to persist through adolescence, and that more attention should be paid to the level of physical activity in later adolescence to prevent inactivity in adulthood (Morseth *et al.* 2011). In particular different ways to increase the amount of physical activity among the most inactive adolescents should be found. It is well known that the amount of physical activity declines through adolescence to adulthood (Telama & Yang 2000; Kemper *et al.* 2001). Therefore the reasons for the difference between the age groups studied here could be high drop-out from physical activity between early (12-15 years) and later adolescence (16-18 years), and lower participation in physical activities at age 37-40 years than at age 41-43 years.

The reasons for the gender differences are not clear. However, aside from differences in the timing of maturation between the sexes (Sherar *et al.* 2010), possible explanation is that males participate more in vigorous physical activity, such as competitive sport in all life phases (Mäkinen *et al.* 2010), while females prefer more individual, flexible and non-competitive physical activities in which they can participate in easily. In addition, physical activity at a young age is more unstable among girls than boys because they participate less than boys in organized and competitive sports, and some life changes, such as getting married and having children, may have a bigger effect on physical activity in adulthood in women than in men (Telama 2009).

6.4 Leisure- time physical activity and fitness in adolescence as predictors of self-estimated fitness in adulthood

In general adult males gave higher estimates of their fitness level than females. The correlation coefficients showed that the level of leisure-time physical activity and physical fitness in adolescence predicts self-estimated fitness in adulthood among both males and females. The level of the associations between physical fitness measured in adolescence and the self-estimated fitness items were higher than leisure-time physical activity in adolescence and the self-estimated fitness items. The results also indicated that the risk for a low self-estimated fitness level in adulthood was significantly lower for subjects who were physically very active or had a high fitness level in adolescence compared to persons with a low activity or low fitness level.

Favourable effects of physical activity for health and fitness have been extensively documented (U.S. Department of Health and Human Services 2008). In the present study, the physical activity index in adolescence correlated on a low level with self-estimated fitness as an adult among both sexes, and the correlation coefficients between adolescent physical activity and adult self-estimated fitness were consistent with the tracking coefficients found for leisure-time physical activity. Previous tracking of physical activity studies have indicated significant but rather moderate or low associations between adolescent and adult leisure-time physical activity, while measured health-related fitness has been shown to track on a moderate level from adolescence to adulthood, although longitudinal studies of physical fitness from youth to adulthood are few (Dennison *et al.* 1988; Barnekow-Bergkvist *et al.* 1998; Telama *et al.* 2005a; Mikkelsson *et al.* 2006).

Among males the highest correlation was found between adolescent leisure-time physical activity and self-estimated speed. Among females the highest correlation was found between adolescent leisure-time physical activity and self-estimated endurance. In contrast, among males, self-estimated flexibility, and among females,

self-estimated speed, correlated with adolescent leisure-time physical activity on the lowest level of the fitness characteristics. As expected, adolescence aerobic fitness correlated on the highest level with adult self-estimated endurance among both sexes. Correspondingly, adolescence muscular fitness correlated on the highest level with adult self-estimated speed. Using a sub-sample of the same cohort as in the present study Mikkelsson *et al.* (2006) found the highest tracking correlations in the sit-and-reach test (r=0.74) for males and sit-up test (r=0.55) for females, with correlation coefficients on the same level as in previous physical fitness tracking studies (Malina 1996; Kemper *et al.* 2001). In addition, when the association between measured (VO_2 max) and self-estimated fitness were studied as an adult, the correlation coefficient between measured and self-estimated endurance was 0.51 among males and 0.43 among females while the coefficients between self-estimated strength and the sit-up test were 0.45 among males and 0.46 among females (Mikkelsson *et al.* 2005). In the present study, the highest correlation coefficients were found between the long distance running scores in adolescence and adult self-estimated endurance (r=0.44) among males and between the muscular fitness index in adolescence and self-estimated speed among females (r=0.43). When the correlation coefficients obtained in this study were compared to the coefficients as an adult (Mikkelsson *et al.* 2005), the differences were rather small. In general, the level of the associations between physical fitness measured in adolescence and the self-estimated fitness items were higher than leisure-time physical activity in adolescence and the self-estimated fitness items. This finding is consistent with the view that physical fitness is strongly influenced by genetic factors and that only a minor part of adult physical capacity can be explained by other important factors, such as regular and continuous physical activity (Barnekow-Bergkvist 1998).

The results showed that risk for adult low self-estimated fitness is appreciably higher among those who are inactive or have a low level of fitness in adolescence compared to their very active or fitter counterparts. Although previous study found that adolescent physical fitness predicted physical activity only among males (Huotari *et al.* 2011), measured fitness in adolescence was significant predictor of self-estimated fitness among both males and females during the same time period. Furthermore, leisure-time physical activity in adolescence predicted self-estimated fitness, although the level of significance was low. Compared to the persons in the high adolescence activity or fitness groups, the persons in low activity and fitness groups had significantly higher risk for adult low self-estimated fitness. Among females the risk levels were slightly higher in relation to the low fitness than physical activity levels, and among males the risk values were rather similar in relation to both the low physical activity and fitness levels. Previous data suggest that those who are fitter in youth tend to be more active in adulthood (Kemper *et al.* 2001) and may in consequence estimate their fitness as high in adulthood. This may be one reason for results obtained a long-term follow-up study of this kind. These findings support the view that different ways to increase the amount of physical activity among the most inactive adolescents should be found.

These results indicated the risk of adult low self-estimated fitness is appreciably higher among those who are inactive or have a low level of fitness in adolescence compared to their very active or fitter counterparts. When the level of the associations between leisure-time physical activity in adolescence and the self-estimated fitness items was compared with that the associations between physical fitness measured in adolescence and the self-estimated fitness items, the latter were higher. The obtained results suggest that a high level of physical activity and fitness in adolescence has a positive effect on self-estimated fitness as an adult.

6.5 Limitations

The main limitation of this study was that physical activity was examined using self-reports only. More reliable results might be obtained by using both objective and self-report research methods. The baseline measurements of this study were carried out in 1976 and at that time objective measurements of physical activity were not readily available. For this reason, physical activity in 2001 was examined by deploying a similar method. Future longitudinal studies should use both self-report questionnaires and diaries, and objective methods, such as accelerometers, to monitor physical activity, as both methods have their own advantages. Objective physical activity monitoring tends to have higher stability and involve a smaller measurement error than self-report methods (Telama 2009). On the other hand, self-report methods may better capture specific activities and seasonal variation (Telama 2009). However, further longitudinal physical activity studies with objective physical activity measurements are needed to verify the tracking of inactivity found in this study.

Another limitation was that the physical activity questionnaires given to the adolescents and adults were not identical because adolescents also participate in school sport (school sport clubs and competitions) and this had to be taken into consideration. Although the questions for adolescents and adults were not the same, the previously examined dimensions of physical activity (i.e., the frequency and intensity of leisure-time physical activity, participation in sport club training and participation in competitive sport events) were investigated at both assessment points and taken into account in calculating the physical activity index. Furthermore, although the age interval was rather long in this study, individual differences in the timing and tempo of the participants' growth spurt and sexual maturation were not controlled for. Recent evidence has indicated interactions between individual differences in maturity status and physical activity and this has to be taken into consideration in the interpretation of the results (Sherar *et al.* 2010).

In addition, physical fitness was measured by field tests instead of laboratory tests. Muscular fitness was measured by four field tests and aerobic fitness by one field

test. Compared with testing in the laboratory, field tests may result in errors at the individual level, although they work rather well at the group level. In physical education in Finland, health-related fitness has been measured by these tests over a long period, and acceptable results for validity and reliability have been reported. Investigation of physical fitness in the laboratory using more sophisticated instruments would have enabled a more detailed description of the fitness characteristics. However, among less active subjects the participation rate in laboratory examinations is likely to be lower than that in school-based measurements.

7 FINDINGS AND CONCLUSIONS

On the basis of the results and within the limitations of the study, the answers to the research questions posed in the study aims are as follows:

1) Consistent with the findings of previous secular trend studies, the boys and girls in 2001 had lower aerobic fitness performance than those in the 1976 sample. The increase in long-distance running time from 1976 to 2001 was among boys 10% and among girls 6%. Distributions of the test results also indicated that polarization in aerobic fitness performance increased during this period.

2) The results indicated differences in the health-related muscular fitness of Finnish adolescents between 1976 and 2001. Compared with the 1976 sample, the 13- to 16-year-old adolescents in 2001 had a slightly higher muscular fitness performance. The results showed a positive trend, in particular in the agility shuttle run and sit-up tests in both boys and girls. In contrast, among boys upper body strength was lower in 2001 than 1976, while in the standing broad jump there was no change in performance over time in boys and only a slight positive trend in girls.

3) Active participation in leisure-time physical activity had an association with high physical fitness in both 1976 and 2001. In contrast, overweight was related to impaired performance in the fitness tests. Furthermore, these determinants explained higher proportion of aerobic and muscular fitness in 2001 than in 1976. Adolescents who were physically active had better aerobic and muscular fitness than adolescents who were physically inactive, and fitness level was highest in the group of adolescents who reported daily participation in leisure-time physical activities. A significant difference in both the aerobic and muscular fitness performances between normal weight and overweight girls and boys was found in both 1976 and 2001. The results are in accordance with the current view that overweight is related to impaired performance in physical fitness tests requiring aerobic fitness, muscle endurance or speed and agility.

4) Leisure-time physical activity in adolescence significantly predicted adult leisure-time physical activity in both males and females. The risk of adult inactivity was lower for subjects who were physically very active in adolescence compared to their inactive counterparts. In males the association between leisure-time physical activity in adolescence and adulthood was significant in both the age group 12-15 and the group 16-18. Among females, the association was found only in the age group 16-18. A high level of fitness at school-age predicted reduced risk for adult physical inactivity among males. However, among females a significant association between the level of fitness in adolescence and adult physical activity was not found.

5) The level of leisure-time physical activity and fitness in adolescence predicts self-estimated fitness in adulthood among both males and females. In general adult males gave higher estimates of their fitness level than adult females. Risk for adult low self-estimated fitness was appreciably higher among those who were inactive or had a low level of fitness in adolescence compared to their very active or fitter counterparts. Although previous study found that adolescence physical fitness predicted physical activity only among males, fitness was a significant predictor of self-estimated fitness in both males and females during the same time period. Comparison of the associations between leisure-time physical activity in adolescence and the self-estimated fitness items in adulthood with the associations between physical fitness measured in adolescence and the self-estimated fitness items in adulthood showed higher values for the latter.

The results of the follow-up indicated that the risk for adult inactivity and low self-estimated fitness was considerably stronger among those who were inactive in adolescence compared to their very active counterparts. The reason for this could be that the association in leisure-time physical activity from adolescence to adulthood is not linear; instead, the associations in inactivity and high level activity between adolescence and adulthood are strong. Although the results of the secular trend study showed a declining trend in adolescents' aerobic fitness performance over time, of greater importance, from the standpoint of a high level of adulthood activity and self-estimated fitness, would be a high level of leisure-time physical activity that would persist from adolescence to adulthood. These findings support the view that it is important to enhance adolescents' physical activity. Due to increased polarization in physical fitness and the increasingly important role of physical activity as a determinant of physical fitness, more attention should be paid to the level of physical activity of the most inactive adolescents. Different ways to increase the amount of physical activity should be found, particularly in later adolescence when every-day physical activities and leisure-time physical activity have been shown to be on the decline.

YHTEENVETO

Fyysinen kunto ja liikunta-aktiivisuus nuoruudessa ja aikuisuudessa – 25 vuoden aikaero- ja seurantatutkimus

Kunto liittyy läheisesti terveyteen ja hyvä fyysinen kunto on keskeinen edellytys yleiselle toimintakyvylle. Maailman terveysjärjestö (WHO) on määritellyt kunnon kyvyksi suoriutua lihasvoimaa vaativasta työstä tyydyttävästi. Kunto jaetaan tavoitteen mukaan suoritus- ja terveyskuntoon. Suorituskunnossa kunnon osa-alueet painottuvat työn tai urheilusuorituksen kannalta tärkeimpiin ominaisuuksiin ja sen osa-alueita ovat motoriset taidot, hengitys- ja verenkiertoelimistön kapasiteetti, voima, nopeus sekä kehon antropometria (koko ja koostumus). Terveyskunto taas koostuu osatekijöistä, joiden voidaan katsoa olevan hyödyllisiä ihmisen arkipäiväisen jaksamisen kannalta. Terveyskuntoon kuuluvien ominaisuuksien harjoittelu tuottaa osoitettuja terveyshyötyjä, jotka suojaavat yksilöä kroonisilta sairauksilta ja ennenaikaiselta kuolemalta. Terveyskuntoon kuuluvia ominaisuuksia ovat hengitys- ja verenkiertoelimistön kestävyys, lihasvoima- ja kestävyys, notkeus sekä kehon koostumus.

Lasten ja nuorten fyysisen kunnon heikentymisestä on viime vuosina käyty runsaasti julkista keskustelua. Tutkimusnäytöt eri puolilta maailmaa osoittavat huolen aiheeliseksi, koska useissa tutkimusraporteissa on osoitettu kuntoominaisuuksien heikentymistä erityisesti kestävyyskunnossa sekä kuntoerojen kasvua hyvä- ja huonokuntoisten välillä. Tulevaisuudessa näillä muutoksilla uskotaan olevan yhteyttä väestön huonompaan terveydentilaan sekä siitä aiheutuviin taloudellisiin lisäkustannuksiin.

Fyysinen aktiivisuus on sukupuolen ja geneettisen perimän lisäksi yksi fyysistä kuntoa säätelevistä tekijöistä. Fyysinen aktiivisuus tarkoittaa kaikkea liikkumista, jonka seurauksena energiankulutus lisääntyy. Fyysinen aktiivisuus on laaja kokonaisuus, joka voidaan jakaa vapaa-ajan fyysiseen aktiivisuuteen, työhön, välimatkojen liikkumiseen sekä päivittäisiin askareisiin. Vapaa-ajan fyysiseen aktiivisuuteen kuuluva liikunta-aktiivisuus sisältää mm. liikunnan harrastamisen, fyysinen harjoittelun sekä kilpailemisen urheilussa. Yksilölliset motiivit ja mieltymykset ovat yhteydessä liikunta-aktiivisuuteen ja näitä motiiveja voivat olla esimerkiksi fyysisen kunnon tai terveyden parantaminen, sosiaaliset kontaktit, esteettiset motiivit, ilo tai vaaran kokeminen.

Vaikka suomalaisten lasten ja nuorten vapaa-ajan liikuntaharrastuneisuuden on osoitettu kasvaneen viimeisten vuosikymmenien aikana, samaan aikaan muutokset joissakin kuntotekijöissä ovat olleet negatiivisia. Tämän kehitykseen on osaltaan arveltu olevan seurausta yhteiskunnan teknistymisen aiheuttamasta arkiliikunnan vähentymisestä. Liikuntaharrastukset ovat aikaisempaa tärkeämmässä roolissa lasten ja nuorten terveyden ja hyvinvoinnin kannalta. Lisäksi liikunta-aktiivisuuden pitkittäistutkimukset ovat osoittaneet lapsuuden ja nuoruuden liikunta-aktiivisuuden olevan yhteydessä aikuisiän liikunta-aktiivisuuteen. Tästä syystä liikuntaharrastuk-

set lapsuudessa ja nuoruudessa voidaan nähdä tärkeänä osana elinikäistä liikunta-harrastusta ja hyvinvointia.

Tämän tutkimuksen tavoitteena oli selvittää vuodesta 1976 vuoteen 2001 tapahtuneita muutoksia nuorten fyysisessä kunnossa liikunta-aktiivisuuden selittämänä sekä tutkia, miten nuoruusiän fyysinen kunto ja liikunta-aktiivisuus ennustavat aikuisiän liikunta-aktiivisuutta ja koettua fyysistä kuntoa.

Vuonna 1976 kerättiin 9–18-vuotiaita koululaisia edustava kunnon ja liikunta-aktiivisuuden poikittaisaineisto (n=2796). Tutkimusaineisto hankittiin 56 koulusta. Kuntoa mitattiin kahdeksalla kenttä testillä (2000/1500/600 metrin juoksu, istumaannousu, leuan veto/koukkukäsiriipunta, sukkulajuoksu, vauhditon pituushyppy, puristus ja vartalon eteentaivutus). Aineiston keräsivät koulutetut mittaajat koulun liikuntatunneilla. Liikunta-aktiivisuutta arvioitiin kyselylomakkeella, jossa oli kysymyksiä liikuntaharrastusten tiheydestä, harrastetuista liikuntamuodoista ja osallistumisesta organisoituun liikuntaan ja kilpailutoimintaan. Lisäksi selvitettiin laajasti opetusryhmä-, koulu-, paikkakunta- ja aluekohtaisia tietoja. Vuonna 2001 kerättiin 11-18-vuotiaan nuoren kunto- ja liikunta-aktiivisuusaineisto vastaavilla mittausta-voilla (n=1041). Osallistuneita kouluja oli 17 ja ne valittiin valtakunnallinen kattavuus huomioiden vuonna 1976 osallistuneiden koulujen joukosta.

Vuoden 2001 seuranta-aineisto muodostettiin edellä mainittuun koulun kuntotutkimukseen vuonna 1976 osallistuneista oppilaista (n=2796), jotka olivat osallistuneet kuntotesteihin ja/tai vastanneet liikunta-aktiivisuuskyselyyn 12–18-vuotiaana. Tämän tutkimuksen lopullinen seuranta-aineisto muodostui 1525 henkilöstä (722 miestä ja 803 naista), jotka olivat osallistuneet kuntomittauksiin ja/tai liikunta-aktiivisuuskyselyyn vuonna 1976 12–18-vuotiaana ja palauttaneet seurantakyselyn vuonna 2001.

25 vuoden aikavälivertailu osoitti kestävyyskunnossa laskevaa ja lihaskunnossa lievästi nousevaa trendiä. Kuntoindeksien ja yksittäisten testien jakaumien tarkastelut osoittivat kuntoerojen kasvaneen siten, että jakaumien ääripäiden väliset erot olivat kasvaneet. Vapaa-ajan liikunaharrastuksen, organisoituun liikuntaan osallistumisen ja kehonpainoindeksin merkitys kuntoa selittävinä tekijöinä oli lisääntynyt tutkimusajankohtien välillä. Vuonna 1976 nämä tekijät selittivät sekä poikien että tyttöjen kestävyyskuntoa 8 % ja vuonna 2001 pojilla 23 % ja tytöillä 34 %. Lihaskunnossa näiden tekijöiden selitysosuus lisääntyi 25 vuoden aikavälillä pojilla 9 %:sta 24 %:iin ja tytöillä 25 %:sta 39 %:iin. Tutkituista muuttujista vuonna 2001 kestävyyskuntoa selittivät parhaiten pojilla kehonpainoindeksi (13 %) ja tytöillä osallistuminen organisoituun liikuntaan ja kehonpainoindeksi (17 %). Vastaavasti lihaskuntoa pojilla selitti parhaiten osallistuminen organisoituun liikuntaan (16 %) ja tytöillä kehonpainoindeksi (21 %).

25-vuoden seurantatutkimuksen tulokset vahvistivat aikaisempien pitkittäistutkimusten antamaa käsitystä nuoruusiän liikunta-aktiivisuuden yhteydestä aikuisiän liikunta-aktiivisuuteen. Korrelaatiotarkastelut osoittivat yhteyden olevan voimakkaampaa pojilla kuin tytöillä sekä vahvistuvan iän lisääntyessä. Pojilla nuoruus- ja aikuisiän liikunta-aktiivisuuden välillä oli yhteyttä sekä nuoremmassa (12–15-vuotiailla) ($r = 0.14$, $p < 0.05$) että vanhemmassa (16–18-vuotialla) ($r = 0.31$,

p<0.001) ikäryhmässä. Sen sijaan tytöillä tilastollisesti merkitsevä yhteys oli ainoastaan vanhemmassa ikäryhmässä (r=0.17, p<0.05). Nuoruusiän kestävyyskunto oli yhteydessä aikuisiän liikunta-aktiivisuuteen ainoastaan poikien vanhemmassa ikäryhmässä (r= 0.19, p<0.05). Sen sijaan tytöillä nuoruusiän kestävyyskunto ja lihaskunto eivät olleet yhteydessä aikuisiän liikunta-aktiivisuuteen. Poikittaistarkastelussa sekä lihaskunto että kestävyyskunto korreloivat liikunta-aktiivisuuden kanssa molemmissa tutkituissa ikäryhmissä. Kuntoindeksien ja liikunta-aktiivisuuden väliset korrelaatiokertoimet vaihtelivat pojilla 0.25–0.44 (p<0.001) ja tytöillä 0.20–0.43 (p<0.001).

Nuoruusiän fyysisen kunnon ja liikunta-aktiivisuuden yhteyttä aikuisiän liikunta-aktiivisuuteen tutkittiin logistisella regressioanalyysilla jakamalla tutkimukseen osallistuneet nuoruusiässä fyysiseltä kunnoltaan ja liikunta-aktiivisuudeltaan kolmeen ryhmään siten, että alimpaan ja ylimpään kunto- ja liikunta-aktiivisuusryhmään kuului noin 20 % tutkittavista. Menetelmällä selvitettiin nuoruusiän eritasoisten kunto- ja liikunta-aktiivisuusryhmien riskiä aikuisiän vähäiseen liikunta-aktiivisuuteen. Tulokset osoittivat, että verrattaessa vähän liikkuvia ja erittäin aktiivisia aikuisiässä, riski vähäiseen liikunta-aktiivisuuteen aikuisena oli yli seitsemän kertaa suurempi vähiten liikkuvilla pojilla, kun heitä verrattiin eniten liikkuviin poikiin (p<0.001). Vastaavasti erittäin aktiivisten tyttöjen riski vähäiseen liikunta-aktiivisuuteen aikuisena oli neljäsosa vähän liikkuvien tyttöjen riskitasoon verrattuna (p=0.001). Verrattaessa aikuisiän vähäisesti ja keskimääräisesti aktiivisia, nuoruusiässä erittäin aktiivisten poikien riski oli lähes kaksi kertaa pienempi (p=0.037) ja tyttöjen yli kaksi kertaa pienempi vähän liikkuviin verrattuna (p=0.004). Fyysiseltä kunnoltaan parhaaseen ryhmään kuuluneilla pojilla riski vähäiseen liikunta-aktiivisuuteen aikuisena oli yli neljä kertaa pienempi heikoimpaan kuntoryhmään kuuluneisiin poikiin verrattuna kun aikuisiän verrokkiryhminä olivat vähän liikkuvat ja erittäin aktiiviset (p=0.020). Tytöillä ei ollut vastaavaa yhteyttä.

Seurantatutkimuksessa selvitettiin myös nuoruusiän liikunta-aktiivisuuden ja fyysisen kunnon yhteyttä aikuisiän koettuun kuntoon. Koettua kestävyyttä, voimaa, nopeutta, notkeutta, sekä selviytymistä erilaisista liikuntasuorituksista juosten, kävellen, pyöräillen tai hiihtäen, selvittävistä kyselylomakkeen kysymyksistä muodostettiin aikuisiän koetun kunnon indeksi, jota verrattiin nuoruusiän liikunta-aktiivisuus- ja kuntoindekseihin. Nuoruusiän liikunta-aktiivisuus oli yhteydessä hyvään koettuun kuntoon aikuisiässä sekä pojilla (r= 0.25, p<0.001) että tytöillä (r=0.24, p <0.001). Korrelaatiokertoimet erikunto-ominaisuuksien kokemisen ja nuoruusiän liikunta-aktiivisuuden välillä vaihtelivat pojilla 0.13 –0.18 ja tytöillä 0.12–0.21. Yksittäisistä kunto-ominaisuuksista nuoruusiän liikunta-aktiivisuuden kanssa voimakkaimmin korreloivat pojilla nopeus ja tytöillä kestävyys. Nuoruusiän kunto oli liikunta-aktiivisuutta voimakkaammin yhteydessä aikuisiässä koettuun kuntoon. Korrelaatiokertoimet nuoruusiän aerobisen kunnon ja aikuisiän koetun kuntoindeksin välillä oli pojilla 0.24 (p<0.001) ja tytöillä 0.32 (p<0.001). Vastaavasti nuoruusiän lihaskuntoindeksin ja aikuisiän koetun kuntoindeksin välinen korrelaatio oli pojilla 0.45 (p<0.001) ja tytöillä 0.38 (p< 0.001). Nuoruusiän kuntoindeksien ja aikuisiässä koettujen yksittäisten kunto-ominaisuuksien väliset korrelaa-

tiokertoimet vaihtelivat miehillä välillä 0.14–0.44 ja naisilla välillä 0.23–0.43. Pojilla voimakkain yhteys oli nuoruusiän kestävyyskunnon ja aikuisiän koetun kestävyyden välillä ja tytöillä nuoruusiän lihaskunnon ja aikuisiän koetun nopeuden välillä.

Nuoruusiän fyysisen kunnon ja liikunta-aktiivisuuden yhteyttä aikuisiän koettuun kuntoon tutkittiin lisäksi logistisella regressioanalyysilla jakamalla tutkimukseen osallistuneet fyysiseltä kunnolta ja liikunta-aktiivisuudeltaan kolmeen ryhmään siten, että alimpaan ja ylimpään kunto- ja liikunta-aktiivisuusryhmään kuului noin 20 % tutkittavista. Vastaavasti alimpaan ja ylimpään koetun kunnon ryhmään kuului noin kolmasosa tutkittavista. Samaa menetelmää käytettiin myös tutkittaessa nuoruusiän kunnon ja liikunta-aktiivisuuden yhteyttä aikuisiän liikunta-aktiivisuuteen. Menetelmällä selvitettiin nuoruusiän eritasoisten kunto- ja liikunta-aktiivisuusryhmien riskiä aikuisiän alhaiseen koettuun kuntoon. Tulokset osoittivat, että verrattaessa fyysisen kuntonsa huonoksi ja erittäin hyväksi tuntevia aikuisiässä, koetun huonokuntoisuuden riski oli molemmilla sukupuolilla yli kaksi kertaa suurempi niillä, jotka kuuluivat nuoruusiässä alimpaan liikunta-aktiivisuusryhmään verrattuna nuoruusiässä ylimpään aktiivisuusryhmään kuuluneisiin ($p<0.001$). Vastaavasti riski aikuisiän koettuun huonokuntoisuuteen niillä, jotka kuuluivat nuoruusiän fyysiseltä kunnoltaan heikoimpaan ryhmään verrattuna nuoruusiän kuntotasoltaan parhaaseen kuntoryhmään kuuluneisiin, oli yli viisinkertainen molemmilla sukupuolilla. ($p<0.001$).

Tämän tutkimuksen tulokset osoittivat, että riski aikuisiän liikunnalliseen vähäiseen liikunta-aktiivisuuteen oli huomattavasti suurempi niillä tutkittavilla, jotka olivat vähän liikkuvia jo nuoruudessa verrattuna liikunnallisesti aktiivisiin ikätovereihin. Vaikka korrelaatiotarkasteluissa yhteys nuoruus- ja aikuisiän liikunta-aktiivisuuden välillä olikin suhteellisen heikko, riskitasojen perusteella voitiin havaita liikunnallisesti vähäisen ja korkean aktiivisuuden olevan yhteydessä aikuisiän vastaavaan liikunta-aktiivisuus- ja koetun fyysisen kunnon tasoon. Vaikka poikittaisvertailu osoittikin laskevaa trendiä nuorten kestävyyskunnossa, aikuisiän liikunta-aktiivisuuden ja koetun kunnon kannalta kuntotasoa tärkeämpi tekijä tämän tutkimuksen perusteella on liikunnallisesti aktiivinen elämäntapa, jokajatkuisi nuoruudesta aikuisikään. Eri aktiivisuusryhmien välisten kuntovertailujen perusteella voidaan päätellä, että liikunnallisesti aktiiviset ovat paremmassa fyysisessä kunnossa nuoruudessa ja kokevat kuntonsa paremmaksi aikuisuudessa. Nämä löydökset yhdessä kasvaneen nuorten fyysisen kunnon polarisoitumisen kanssa tukevat näkemystä liikunta-aktiivisuuden edistämisen tarpeesta erityisesti kaikkein vähiten liikkuvien nuorten keskuudessa. Tämän tutkimuksen tulosten pohjalta erityistä huomiota liikunta-aktiivisuuden edistämiseen tulisi kiinnittää hieman ennen aikuisikää (16–18-vuotiaana), jolloin vapaa-ajan liikunta-aktiivisuus vähenee, mutta toisaalta liikunta-aktiivisuuden yhteys aikuisiän liikunta-aktiivisuuteen on kaikkein voimakkainta.

Tämä tutkimus vahvisti aikaisempaa käsitystä liikunta-aktiivisuuden ja fyysisen kunnon välisestä yhteydestä sekä nuoruusiän liikunta-aktiivisuuden merkityksestä aikuisiän liikunta-aktiivisuuden kannalta. Aikaväli vertailu kuitenkin osoitti

liikunta-aktiivisuuden merkityksen lisääntyneen nuorten fyysisen kunnon selittäjänä. Liikunnallisesti aktii visiin verrattuna li ikunnallisesti passi ivisilla n uorilla on sekä huonompi f yysinen k unto että merkittävästi aktiivisia nuoria suurempi riski a i-kuisiän inaktiivisuuteen ja matalaan koettuun kuntotasoon ja siitä mahdollisesti seu-raaviin terv eysongelmiin. Kansa nterveyden näkökul masta lii kuntakasvatuksessa tulisikin oso ittaa aikais empaa suure mpia voi mavaroja ja resur sseja liian vähän lii k-kuvien nuorten liikunta-aktiivisuuden edistämiseen.

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APPENDICES

Appendix 1. Letter to the headmasters

Arvoisa koulunjohtaja/rehtori

LIKES-tutkimuskeskuksen Lasten ja nuorten elämäntavan tutkimusyksikössä (LINET) toteutetaan keväällä 2001 koululaisten liikuntatutkimusta, jossa kartoitetaan **koululaisten fyysistä kuntoa ja sen muutoksia 25 vuoden aikavälillä**. Tutkimus on osa projektia, jossa pyritään selvittämään fyysisen kunnon ja terveyden välisiä yhteyksiä. Tutkimuksen rahoittajina ovat Opetusministeriö ja kaksi säätiötä.

Vuonna 1976 kerättiin 9-18-vuotiaiden koululaisten fyysisen kunnon ja liikunta-aktiivisuuden aineisto, johon osallistui 2800 koululaista eri puolilta maata. Myös teidän koulunne osallistui silloin tähän tutkimukseen. Huhti- toukokuussa 2001 hankitaan n. 1000 nykynuoren otos, jonka ikäjakauma sekä lääni-, paikkakunta ja koulukohtaiset tiedot on suhteutettu vuoden 1976 otoksen mukaiseksi. Näille nuorille tehdään samat fyysisen kunnon testit ja kysely kuin vuonna 1976. Keräämällä samat taustatiedot kuin vuonna 1976 voidaan verrata, eroaako nykykoululaisten kunto vuoden 1976 samanikäisten koululaisten kunnosta sekä onko koululaisten kuntoa selittävät tekijät muuttuneet 25 vuoden aikana.

Tutkimuksessa mitataan peruskoululaisten (5-, 7- ja 9-luokkalaisten) sekä lukion (I tai II vuosi) oppilaiden kuntoa ja liikunta-aktiivisuutta. Fyysisen kunnon mittaaminen suoritetaan koulun kuntotestistöllä, johon kuuluu seitsemän testiosiota (testikuvaukset lähetetään liikunnanopettajille). Testien toteuttamisesta vastaisi erillinen testiryhmä, joka tulisi kouluunne suorittamaan testit sovittuna päivänä. Mittaukset suoritettaisiin liikuntatunneilla ja ne kestävät yhtä ryhmää kohti yhden kaksoistunnin. Yhteen mittausryhmään kuuluvat sekä tyttöjen että poikien liikuntaryhmät, kuitenkin yhteensä enintään 30 oppilasta. Testiryhmä viipyisi koulullanne yhden päivän ja sen tavoitteena olisi mitata mahdollisimman monta opetusryhmää. Lisäksi oppilaat täyttävät mittausten yhteydessä omaa liikunta-aktiivisuuttaan ja terveystottumuksiaan kartoittavan kyselylomakkeen, joka toimitetaan Teille ja liikunnanopettajille etukäteen tutustuttavaksi.

Pyydämme Teiltä lupaa saada toteuttaa edellä kuvatut mittaukset koulussanne ajankohtana, joka Teille sopii. Otamme teihin yhteyttä helmi-maaliskuun aikana.

Yksittäistä koulua, opettajaa tai oppilasta koskevat tiedot säilytetään luottamuksellisena ja kaikkia tietoja käsitellään ainoastaan suuremmissa ryhmissä. Tutkimuksen tuloksista tiedotetaan koululle ja raportoidaan kotimaisissa liikunta-alan julkaisuissa.

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Appendix 2. Letter to the PE teacher

LIKES -tutkimuskeskus
Lasten ja nuorten elämäntavan tutkimusyksikkö
Yliopistonkatu 20
40100 Jyväskylä

ARVOISA OPETTAJA

LIKES -tutkimuskeskuksen Lasten ja nuorten elämäntavan tutkimusyksikössä toteutetaan kevään 2001 aikana **suomalaisten koululaisten kuntoa kartoittava tutkimus, jossa selvitetään kunnon muutoksia 25 vuoden aikavälillä sekä nykykoululaisten fyysistä kuntoa selittäviä tekijöitä**. Kuntoaineiston avulla pyritään laatimaan ennustemalleja lähitulevaisuudessa odotettavissa olevasta koululaisten kunnon ja terveyden kehityksestä. Koulunne rehtori on myöntänyt luvan tutkimusaineiston keräämiseen koulussanne.

Vuonna 1976 kerättiin 9-18-vuotiaiden koululaisten fyysisen kunnon ja liikunta-aktiivisuuden aineisto, johon osallistui 2800 koululaista eri puolilta maata. Teidän koulunne osallistui silloinkin tähän tutkimukseen. Kevään 2001 aikana hankitaan n. 1000 nykynuoren otos, jonka ikäjakauma sekä lääni-, paikkakunta ja koulukohtaiset tiedot on suhteutettu vuoden 1976 otoksen mukaiseksi. Näille nuorille tehdään samat fyysisen kunnon testit ja kysely kuin vuonna 1976. Keräämällä samat taustatiedot kuin vuonna 1976 voidaan verrata, eroaako nykykoululaisten kunto vuoden 1976 samanikäisten koululaisten kunnosta sekä onko koululaisten kuntoa selittävät tekijät muuttuneet 25 vuoden aikana.

Tutkimuksessa mitataan peruskoululaisten (5-, 7- ja 9-luokkalaisten) sekä lukion (I tai II vuosi) oppilaiden kuntoa ja liikunta-aktiivisuutta kevään 2001 aikana. Fyysisen kunnon mittaaminen suoritetaan koulun kuntotestistöllä, johon kuuluu seitsemän testiosiota (testikuvaukset liitteenä). Testien toteuttamisesta vastaa erillinen testiryhmä, joka tulee kouluunne mittaamaan sovittuna päivänä. Mittaukset suoritettaisiin liikuntatunneilla ja ne kestävät yhtä ryhmää kohti yhden kaksoistunnin. Yhteen mittausryhmään kuuluvat sekä tyttöjen että poikien liikuntaryhmät, kuitenkin yhteensä enintään 30 oppilasta. Mittausryhmä viipyy koulullanne yhden päivän ja sen tavoitteena on mitata mahdollisuuksien mukaan 80-100 oppilasta. Nopeuden (50 metrin juoksu) sekä kestävyyden (2000/1500/600 metrin juoksu) mittaamisen toivoisimme teidän hoitavan liikuntatunnilla parhaaksi sopivana ajankohtana toukokuun aikana ja lähettävän näiden testien tulokset palautuskuoressa LIKES -tutkimuskeskukseen. Lisäksi oppilaat täyttävät lihaskuntomittausten yhteydessä omaa liikunta-aktiivisuuttaan ja terveystottumuksiaan kartoittavan kyselylomakkeen.

Tutkimuksen onnistumiseksi pyytäisimme Teiltä seuraavaa:

1. **Tiedottaminen mittauksiin osallistuvien oppilaiden vanhemmille oheisella tiedotteella**
2. **Testattavat oppilaat:**
   - testataan opetusryhmittäin, pyrkimyksenä saada mittauksiin puolet tyttöjä ja puolet poikia. Mikäli oppilaita on paljon mittaajat valitsevat sopivan määrän testattavia.
   - Pyydämme teitä tarkistamaan etukäteen terveydenhuoltohenkilökunnalta ja/tai oppilaan huoltajalta, onko mitattavassa opetusryhmässä oppilaita, jotka sairastavat vaikeaa astmaa, vaikeaa sokeritautia, synnynnäistä sydänvikaa tai muuta testin estävää sairautta. Nämä oppilaat eivät saa ottaa osaa mittaukseen. Lisäksi oppilaat, jotka mittauspäivänä eivät tunne olevansa terveitä (sairastavat tai ovat äskettäin sairastaneet akuuttia infektiotautia), eivät myöskään osallistu tutkimukseen. Heidän tilalleen valitsemme tarvittaessa vastaavan määrän oppilaita.
3. **Mittaustilan ja välineiden järjestäminen**
   - Koulun liikuntasalin varaaminen mittauskäyttöön tarvittaessa koko päiväksi
   - Tarvittavat välineet: voimistelupenkkejä 2 kpl, rekkitanko, ponnistuslauta, voimistelumattoja
4. **Opettajan kyselylomakkeen täyttäminen**
5. **Juoksutestien järjestäminen**
   - 50 ja 2000/1500 metrin juoksutestien järjestäminen lihaskuntomittauksiin osallistuneille oppilaille opetusohjelmaan parhaiten sopivana ajankohtana ja tulosten lähettäminen LIKES -tutkimuskeskukseen

Yksittäistä koulua, opettajaa tai oppilasta koskevat tiedot säilytetään luottamuksellisena ja kaikkia tietoja käsitellään ainoastaan suuremmissa ryhmissä. Tutkimuksen tuloksista tiedotetaan koululle ja raportoidaan kotimaisissa liikuntaalan julkaisuissa.

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Appendix 3. Letter to the parents

Tiedote vanhemmille

LIKES -tutkimuskeskuksen Lasten ja nuorten elämäntavan tutkimusyksikössä (LINET) toteutetaan keväällä 2001 koululaisten liikuntatutkimusta, jossa kartoitetaan koululaisten fyysistä kuntoa ja sen muutoksia 25 vuoden aikavälillä. Tutkimus on osa projektia, jossa pyritään selvittämään fyysisen kunnon ja terveyden välisiä yhteyksiä. Tutkimusaineisto kerätään eri puolilta Suomea liikuntatuntien puitteissa tehtävillä kuntotesteillä, jotka järjestetään satunnaisesti valituille oppilasryhmille. Testinä käytetään koulun kuntotestistöä, jota on käytetty yleisesti koululaisten fyysisen kunnon mittaamiseen. Keski-Suomen sairaanhoitopiirin eettinen toimikunta on 6.3.2001 antanut puoltavan lausunnon tutkimussuunnitelmasta.

Lapsenne kuuluu testattavaan opetusryhmään. Liikunnanopettaja tiedottaa oppilaille testipäivämäärän ja oppilaiden tulisi testipäivänä varata mukaansa sisäliikuntavarustus.

Yksittäistä koulua, opettajaa tai oppilasta koskevat tiedot säilytetään luottamuksellisena ja kaikkia tietoja käsitellään ainoastaan suuremmissa ryhmissä. Tutkimuksen tuloksista tiedotetaan koululle ja raportoidaan kotimaisissa liikuntaalan julkaisuissa.

Appendix 4. Pre-questionnaire in fitness test

KUNTOTESTIIN SOVELTUVUUS

Nimi _____

Vastaa jokaiseen kysymykseen kyllä tai ei	**kyllä**	**ei**
1. Onko Sinulla sydänvikaa tai -sairautta?	_____	_____
2. Ovatko nivelesi kipeät, tulehtuneet tai turvonneet?	_____	_____
3. Tunnetko kävellessä ahdistusta, polttoa tai puristusta rinnassasi?	_____	_____
4. Pyörryttääkö tai huimaako Sinua kävellessä?	_____	_____
5. Tunnetko itsesi poikkeavan väsyneeksi?	_____	_____
6. Onko Sinulla kuumetta?	_____	_____

Jos vastasit kaikkiin kysymyksiin "ei", voit suorittaa testin turvallisesti. Jos vastasit yhteen tai useampaan kysymykseen "kyllä", kysy neuvoa testaajilta.

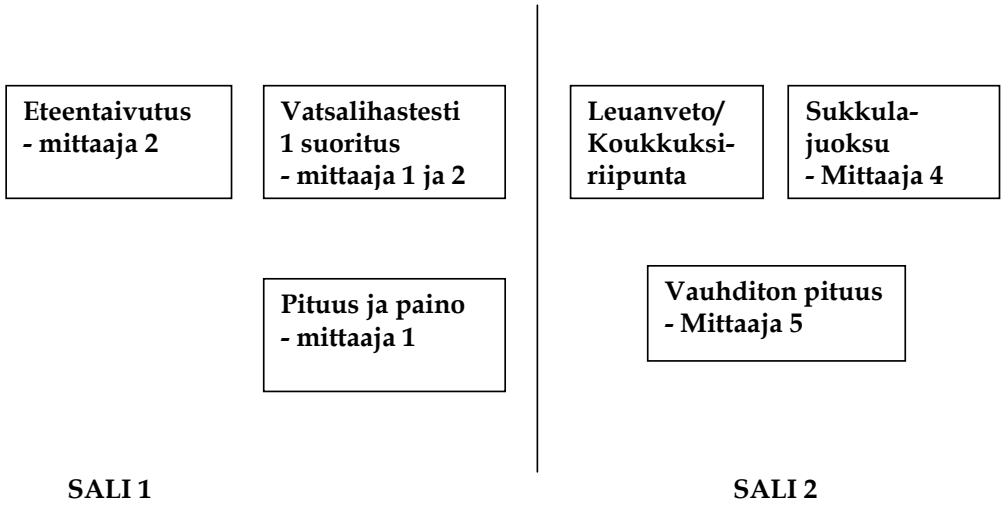
Appendix 5. Fitness test procedure

KUNTOTESTIEN KULKUKAAVIO

Liikuntasali jaetaan kahteen osaan (1 ja 2), joissa molemmilla puolilla suoritetaan eri testiosioita. Sali 1 puolella oppilailta mitataan pituus ja paino, suoritetaan vatsalihastesti sekä eteentaivutus. Sali 2 puolella suoritetaan vauhditon pituus, leuanveto/koukkukäsiriipunta sekä viivajuoksu. Kuntotestien jälkeen oppilas täyttää kyselylomakkeen. Tunti aloitetaan yhteisellä n. 5 min alkuverryttelyllä, jonka jälkeen oppilaat jaetaan salin eri puoliskoille. Suosituksena on, että ryhmä jaettaisiin sukupuolen mukaan salin eri puoliskoille.

Sali 1 puolella mittaukset toteutetaan siten, että ensin tehdään vatsalihastesti kahdessa erässä (pareittain siten, että toinen pitelee jaloista ja laskee suoritukset). Testin jälkeen mittaaja ottaa tulokset ylös ja oppilaat jaetaan kahteen ryhmään. Toinen ryhmistä menee pituuden ja painon mittaukseen ja toinen eteentaivutustestiin. Jokaisen oppilaan suoritettua testit ryhmät vaihtavat testipaikkoja. Mittaajia tulisi olla vähintään kaksi, joiden tehtävät jakautuvat siten, että vatsalihastestin jälkeen mittaaja 1 ottaisi ylös oppilaiden pituuden ja painon. Mittaaja 2 ottaisi ylös vatsalihastestien tulokset ja siirtyisi sen jälkeen valvomaan eteentaivutustestiä.

Sali 2 puolella kullakin testipaikalla on oma mittaaja, joka laskee suoritukset ja merkitsee ne oppilaan kuntokorttiin.



Mittauksissa kiinnittäkää huomiota erityisesti seuraaviin asioihin:

1. Sukkulajuoksu vaatii tarkkoja ohjeita palikan pudottamisen tai heittämisen sääntöjenvastaisuudesta.

2. Sukkulajuoksu vie runsaasti aikaa, joten testin sujuvuuteen kiinnitettävä huomiota.

3. Leuanvedossa on estettävä kädellä vartalon heilautukset ja potkut

4. Istumaannousutestissä on korostettava sekä suorittajan että avustajan tarkkaa suorituskertojen laskemista

5. Istumaannousutestissä on valvottava kyynärpäiden osoittamista eteen koko suorituksen ajan.

6. Magnesiumin käyttö vauhdittomassa pituushypyssä on välttämätöntä, hyvä lisävaruste on esim. taulusieni, jolla pyyhitään entiset jäljet pois.

7. Leuanvedossa ja koukkukäsiriipunnassa valvottava, että suorittajalla on myötäote.

8. Koukkukäsiriipunnassa leuan kevyt kosketus rekkiin ei johda kellon pysäyttämiseen, vaan vasta selvä nojaaminen.

Mittausryhmän olisi hyvä varata mukaansa ainakin 2-4 sekuntikelloa ja mittanauhoja, digitaalivaaka, magnesiumia, kyniä, sukkulajuoksussa tarvittavat palikat sekä maalarinteippiä

Appendix 6. Fitness test instructions

PITKÄN MATKAN JUOKSU 600/1500/2000 m

Välineet: Sekuntikello ja tarkasti mitattu matka.

Juoksumatkat: Yli 12 v pojat 2000m
Yli 12 v tytöt 1500m
Alle 12 v tytöt ja pojat 600m

Testin suorittaminen: Suullisesta komennosta "paikoillenne" suorittajat asettuvat lähtöviivan taakse toinen jalka edessä (pystylähtö). Kun kaikki ovat liikkumatta, annetaan komento "nyt", jonka jälkeen oppilaat juoksevat matkan mahdollisimman nopeasti. Käveleminenkin on sallittua, mikäli se on testattavan heikon juoksukunnon kannalta välttämätöntä.

Yleisiä ohjeita: Juoksualustan tulisi olla tasainen ja kohtuullisen kovapohjainen. Sääolosuhteiden tulisi olla normaalit, mikä tarkoittaa juoksun välttämistä erityisesti kovassa sateessa tai äärimmäisissä lämpötiloissa. Testattavien kestävyyskunnon selvittämiseksi oppilaita tulisi motivoida yrittämään parastaan.

VAUHDITON PITUUSHYPPY

Välineet: Koroke, jonka yläpinta on alastulopaikan tasolla (esim. ponnituslauta, jonka korkeampi pää on seinää vasten). Korokkeen reuna ei saa olla terävä. Kaksi mittanauhaa kiinnitetään maalarinteipillä lattiaan yhdensuuntaisina kohtisuoraan ponnistusviivaa vasten alastulopaikan välittömään läheisyyteen noin puolen metrin etäisyydelle alastulopaikasta. Alastulopaikalle asetetaan kaksi voimistelumattoa peräkkäin liukumisen estämiseksi. Ponnistuspaikan läheisyyteen varataan magnesiumia, jota hierotaan kantapäihin ennen hyppyä. Kaikki hyppäävät avojaloin.

Testin suorittaminen: Suorittaja asettuu ponnistuskorokkeen reunalle siten, että varpaat voivat ulottua reunan yli. Hän saa hypätä heti, kun on valmis. Tehtyään käsillään valmistavan taakseheilautuksen, heilautetaan kädet voimakkaasti eteenpäin ja ponnistetaan molemmilla jaloilla yhtä aikaa niin kauas kuin mahdollista. Jokaisella suorittajalla on kaksi perättäistä yritystä.

Tulos: Lopulliseksi tulokseksi merkitään parempi kahdesta hypystä.

Yleisiä ohjeita: Hypyn pituus katsotaan siitä kohdasta, missä taaempi kantapää on koskettanut mattoon. Jos suorittaja menettää tasapainonsa taaksepäin,

rikkoo ponnistusviivan tai koskettaa alastulopaikkaa jollakin muulla kehon osallaan, hänelle annetaan uusi yritys. Jalkojen on pysyttävä kiinni korokkeessa ponnistushetkeen saakka.

Suorituksessa voidaan käyttää testaajan lisäksi avustajaa, joka toimii myös hyppytuloksen mittaajana opettajan vastakkaisella puolella. Tulosten kirjaajana voi niin ikään olla joku oppilaista.

LEUANVETO

Testi on tarkoitettu yli 12 -vuotiaille pojille

Välineet: Rekkitankoja 1-2 kappaletta, penkki tai jakkara sekä magnesiumia

Rekkitangot tulee asentaa niin korkealle, että luokan pisimmät oppilaat voivat riippua varpaiden koskettamatta maahan.

Testin suorittaminen: Suorittaja tarttuu tankoon myötäotteella, jolloin kämmenet ovat suorittajasta poispäin. Kädet pidetään hartialeveyden päässä toisistaan.
Suoritus aloitetaan riipunnasta, jolloin kädet on ojennettu suoriksi ja jalat eivät kosketa lattiaa.
Testattavat koukistavat käsivartensa ja nostavat leukansa niin monta kertaa kuin jaksavat juuri rekkitangon yläpuolelle. Tämän jälkeen lasketaan vartalo alas ojentamalla kädet suoriksi. Jokaisella suorittajalla on vain yksi suorituskerta. Tulokseksi lasketaan suorituskerrat, jolloin leuka on kohotettu tangon yläpuolelle.

Yleisiä ohjeita: Ennen testin suorittamista tarkistetaan, että kaikki oppilaat ovat avojaloin ja suoritusvuorossa oleva on hieronut kämmeniinsä magnesiumia. Suoritusvuoroaan odottavat, samassa testipisteessä olevat oppilaat voivat toimia avustajina ehkäisemällä vartalon heilumista eteenpäin ojentamalla kätensä suorittajan reisien tai polvien eteen.

Testi lopetetaan, mikäli suorittaja lepää suorituksensa aikana pitkähkön ajan(n. 2 s tai kauemmin) tai ei onnistu kohottamaan leukaansa tangon yläpuolelle kahdella peräkkäisellä yrityksellä. Lisäksi käsien suoriksi ojentamisesta on huolehdittava suorituksen aikana.

Testaaja laskee suorituskerrat ja valvoo suoritusta.

Testin liitteenä piirros oikeasta suoritustavasta

KOUKKUKÄSIRIIPUNTA

Tämä testi on tarkoitettu tytöille ja alle 12 -vuotiaille pojille

Välineet: Sekuntikello, 1-2 rekkitankoa, penkki tai jakkara sekä magnesiumia. Rekkitanko tulee asentaa niin korkealle, että luokan pisimmät oppilaat voivat riippua kädet koukussa ilman, että varpaat koskettavat lattiaan. Penkit tai jakkarat asetetaan telineiden alle.

Testin suorittaminen: Suorittaja nousee penkille ja tarttuu myötäotteella tankoon, jolloin kämmenpohjat ovat suorittajasta poispäin. Kädet ovat täysin koukistettuina, leuka juuri tangon yläpuolella. Testaaja antaa lähtömerkin, jolloin suorittaja irrottaa jalkansa tuolilta ja nostaa leukansa tangon yläpuolelle. Samalla hetkellä testaaja käynnistää kellon. Koehenkilö jää riippumaan kädet koukistettuina leuka tangon yläpuolella niin pitkäksi aikaa kuin jaksaa. Jokaisella suorittajalla on vain yksi yrityskerta. Tulos ilmoitetaan sekunteina (pyöristettynä lähimpään sekuntiin), jonka suorittaja pysyi hyväksytyssä asennossa.

Yleisiä ohjeita: Ennen testin aloittamista tarkistetaan, että suorittaja on avojaloin. Leuka täytyy pitää koko ajan juuri tangon yläpuolella ja irti tangosta. Mikäli leuka koskettaa tankoon tai laskeutuu sen alapuolelle suoritus lopetetaan. Testaajan oikea-aikainen toiminta suorituksen alussa ja lopussa on tärkeää.

Testin liitteenä piirros oikeasta suoritustavasta

SUKKULAJUOKSU

Välineet: Sekuntikello ja liitua. Voimistelusalin lattialle tai tasaiselle radalle mitataan 10 m:n matka, jonka molempiin päihin piirretään yhdensuuntaiset rajaviivat (ks. piirros). Rajaviivojen päihin piirretään puoliympyrät (säde= 50 cm) keskipiste rajaviivalle. Lisäksi tarvitaan kaksi puupalikkaa (4x4x4 cm tai 5x5x5 cm). Lähtöviivan vastakkaiseen puoliympyrään asetetaan molemmat puupalikat puoliympyrän sisäpuolelle rajaviivalle n. 15 cm:n päästä toisistaan.

Testin suorittaminen: Oikean suoritustavan esityksen jälkeen kukin testattava vuorollaan asettuu lähtöviivan taakse toinen jalka edessä komennolla "paikoillanne" (pystylähtö). Kun suorittaja on liikkumatta annetaan komento "nyt" ja samanaikaisesti painetaan kello käyntiin.

Testattava juoksee niin nopeasti kuin pystyy kohti vastakkaista rajaviivaa, poimii ensimmäisellä kerralla käteensä toisen puoliympyrässä olevista palikoista ja juoksee takaisin lähtöviivalle asettaen siellä olevaan puoliympyrään poimimansa palikan. Ilman taukoa suorittaja juoksee jälleen takaisin ja palaa mukanaan toinen palikka asettaen sen lähtöympyrään.

Kello pysäytetään samalla kun palikka kolahtaa lattiaan. Mikäli palikka jää puoliympyrään, testaaja ilmoittaa ajan ja kirjaa sen. Aika otetaan lähtömerkistä siihen hetkeen, kun viimeinen palikka on asetettu lähtöympyrään. Aika pyöristetään lähimpään sekunnin kymmenykseen.

Yleisiä ohjeita: Kaikkien tulisi suorittaa testi avojaloin tai sisäpelikengät jalassa. Suoritusrata tulee piirtää valmiiksi ennen tunnin alkua. Lähtöviiva on vedettävä riittävän kauaksi seinästä (4-5 m). On korostettava, että palikoita ei saa heittää eikä pudottaa puoliympyrään. Suoritus mitätöidään, mikäli näin tehdään. Uusi suoritus annetaan, mikäli testattava liukastuu, kaatuu matkalla tai palikka putoaa kädestä. Mikäli epäonnistuminen tapahtuu aivan juoksun lopussa ei uusintaa pidä järjestää välittömästi, vaan n. 3 min palautuksen jälkeen.

Testi vie suhteellisen paljon aikaa, joten joustavaan etenemiseen on kiinnitettävä huomiota. Heti kun edellinen suoritus on päättynyt, asettuu seuraava valmiiksi, jona aikana testaaja käy asettamassa palikat vastakkaiselle rajaviivalle.

ISTUMAANNOUSUTESTI

Välineet: Mattoja, sekuntikello

Testin suorittaminen: Testattavat asettuvat selinmakuulle matolle tai muulle riittävän pehmeälle alustalle jalat nilkkojen kohdalta noin 30 cm:n etäisyydeltä toisistaan. Polvet koukistetaan suoraan kulmaan. Kädet tuetaan niskan, ei takaraivon, taakse sormet ristissä (sormet painetaan tiukasti toistensa lomiin). On tärkeää, että kyynärpäät osoittavat ylöspäin. Tämä varmistetaan kehottamalla painamaan kyynärvarret korvia vasten. Avustajat asettuvat polvilleen suorittajien viereen ja painavat käsillään näitä jalkateristä lattiaa vasten.

Kun kaikki on valmista, antaa testaaja komennon "aika alkaa - nyt", jolloin nyt -sanalla painetaan kello käyntiin.

Suoritusaika on 30 sekuntia ja tämän kuluttua annetaan komento "seis", jolloin kello pysäytetään.

Suorittajat nousevat 30 sekunnin ajan selinmakuulta ylös niin nopeasti ja usein kuin on mahdollista ilman taukoja. Oikea suoritus on sellainen, jossa makuuasennossa kädet koskettavat lattiaan kyynärvarsia levittämättä ja istuma-asennossa kyynärpäät vastaavasti koskettavat polviin. Suorituskertoja on yksi kutakin testattavaa kohden. Tulos on täydellisten ylösnousujen määrä 30 sekunnin aikana.

Yleisiä ohjeita: Suoritukset tapahtuvat siten että, puolet ryhmästä on ensin suorittajina ja puolet avustajina. Suorittajien vaihto tapahtuu yhtäaikaisesti. Lantion käyttöä ylösnousussa ei tule sallia. On pyrittävä yhtäjaksoiseen suoritukseen, mutta suoritusta ei tule hylätä, jos tauot ovat välttämättömiä.

Tulokset merkitään kunkin ryhmän osalta yhtä aikaa ja sekä suorittajat että avustajat osallistuvat laskemiseen. Kaikkien suoritusten tulisi tapahtua matolla tai muuten pehmeällä alustalla. Mikäli mattoja ei ole riittävästi, voivat jalat olla lattialla mattojen ulkopuolella. Kuitenkin on varmistuttava, että päiden alle jää riittävästi mattopintaa.

Ennen testiä kaikki testattavat kootaan mattojen äärelle ja näytetään oikea suoritustapa sekä avustamisote.

Testin liitteenä piirrokset oikeasta suoritustavasta.

Appendix 7. Student fitness card

KUNTOKORTTI **Koehenkilön numero** _____

Sukunimi _____
Mittauspäivämäärä _____

Etunimet _____
(puhuttelunimi alleviivataan)

Koulu _____

Syntymäaika ____**pv** _____**kk** _____ **vuosi**

FYYSISET TAUSTATIEDOT

Pituus _____ **cm**

Paino _____ **kg**

KUNTOSUORITUKSET	**1 yritys**	**2 yritys**
Vauhditon pituus (cm)	_____	_____
Leuanveto (lkm)	_____	
Koukkukäsiriipunta (s)	_____	
Sukkulajuoksu (1/10 s)	_____	_____
Istumaannousu (lkm/30 s)	_____	
Eteentaivutus (cm)	_____	_____
600 m juoksu	_____	
1500 m juoksu	_____	
2000 m juoksu	_____	

Apendix 8. Questionnaire 1976 and 2001

OPPILAAN KYSELYLOMAKE

_____ _____ _____

Sukunimi Etunimi Koulu

Täytä lomake merkitsemällä **rasti (x)** mielestäsi parhaan vaihtoehdon kohdalle tai **kirjoittamalla** vastaus sitä varten varattuun tilaan. Vastaa huolellisesti **jokaiseen** kysymykseen ja **palauta** lomake testaajalle.

1. Kuinka pitkä matka on kotoasi koululle (yhteen suuntaan 0,5 km:n tarkkuudella)

_____ kilometriä

2. Miten tavallisesti kuljet koulumatkasi?

kävellen ( )
pyörällä ( )
linja-autolla ( )
muuten, miten ( )
_____
_____

3. Mitä urheilu- ja liikuntavarusteita omistat. Merkitse rasti (x) jokaisen omistamasi välineen kohdalle.

Omistan	varusteet ja välineet	Omistan	varusteet ja välineet
( )	Polkupyörä	( )	Pesäpalloräpylä
( )	Maastohiihtovälineet	( )	Jalkapallo
( )	Lasketteluvälineet	( )	Sulkapallomaila
( )	Luistimet	( )	Kuula, keihäs tai kiekko
( )	Kompassi	( )	Voimailuvälineitä, mitä
( )	Piikkarit		_____
( )	Lenkkikengät		
	_____		
( )	Jalkapallokengät	( )	Muita välineitä, mitä
( )	Uimapuku tai -housut		_____
( )	Verryttelypuku		
	_____		
( )	Voimistelupuku		
	_____		
( )	Jääpelimaila		
	_____		

4. Osallistutko koulun liikuntakerhoon?

Koululla ei ole liikuntakerhoa	( )
En osallistu	( )
Osallistun silloin tällöin	( )
Osallistun viikoittain	( )

5. Kuinka usein harrastat liikuntaa koulutuntien ulkopuolella vähintään puoli tuntia kerrallaan?

en lainkaan	( )
joka päivä	( )
2-6 päivänä viikossa	( )
kerran viikossa	( )
2-3 kertaa kuukaudessa	( )
kerran kuukaudessa	( )
harvemmin kuin kerran kuukaudessa	( )

6. Mitä seuraavista liikuntalajeista harrastat koulutuntien ulkopuolella <u>säännöllisesti viikoittain</u> niinä vuodenaikoina, kun siihen on mahdollisuus

kävely ……	( )
pyöräily ……	( )
juoksu (pikamatkat 50- 400m) ……. ……	( )
juoksu (pitkät matkat yli 400 m) ……	( )
yleisurheilun hyppylajit ……...	( )
yleisurheilun heittolajit ……	( )
telinevoimistelu ……	( )
aerobic ……	( )
tanssi ……	( )
kuntosaliharjoittelu, voimaharjoittelu ……	( )
laskettelu ……	( )
lumilautailu ……	( )
rullalautailu, skeittailu ……	( )
maastohiihto ……	( )
suunnistus, retkeily ……	( )
luistelu ……	( )
uinti ……(	)
jalkapallo ……	( )
koripallo/katukoris……..	( )
salibandy, sähly ……..	( )
lentopallo ……	( )
sulkapallo ……	( )
jääkiekko ……	( )
pesäpallo ……	( )
muu, mikä _____	( )

7. Käytkö urheiluseuran harjoituksissa

		Mikä laji
En	( )	
Kyllä. Silloin tällöin.	( )	_____
Kyllä. Säännöllisesti	( )	_____

8. Oletko osallistunut viimeisen vuoden aikana urheilukilpailuihin

		Mikä laji
En	( )	
Kyllä. Koulun tai koulujen välisiin	( )	_____
Kyllä. Urheiluseuran kilpailuihin	( )	_____
Kyllä. Piirin kilpailuihin	( )	_____
Kyllä. Valtakunnallisiin kilpailuihin	( )	_____
Kyllä. Kansainvälisiin kilpailuihin	( )	_____

9. Mitä mieltä olet koulun liikuntatunneista?

Pidän kovasti liikuntatunneista	( )
Pidän liikuntatunneista	( )
Eivät ole kovin vastenmielisiä, mutta eivät miellyttäviäkään	( )
En pidä liikuntatunneista	( )
Pidän liikuntatunteja hyvin vastenmielisinä	( )
En osallistu liikuntatunneille	( )

10. Mistä koulussasi harjoitetuista liikuntalajeista pidät eniten (1), mistä seuraavaksi (2) ja mistä kolmanneksi (3) eniten. Mainitse tässä järjestyksessä.

1. _____
2. _____
3. _____

11. Mistä koulussasi harjoitetuista liikuntalajeista pidät vähiten tai et pidä lainkaan.

1. _____
2. _____
3. _____

12. Mikä oli liikuntanumerosi edellisessä todistuksessa?

_____

13. Kuinka monta vuotta nykyinen liikunnanopettajasi on opettanut sinua?

_____ vuotta

KIITOS VAIVANNÄÖSTÄ!!!!

Appedix 9. Follow-up questionnaire

Liikuntakasvatuksen
tutkimus- ja kehittämiskeskus

LINKKI

ARVOISA VASTAANOTTAJA

Te osallistuitte vuonna 1976 koululaisten liikuntaa koskevaan tutkimukseen. Nyt, lähes 25 vuotta sen jälkeen pyrimme selvittämään, minkälainen on elämän- ja terveystilanteenne sekä minkälaista on fyysinen aktiivisuutenne nykyisin. Olemme kiitollisia, jos voitte olla auttamassa tämän kansallisesti ja kansainvälisestikin merkittävän tutkimuksen toteuttamisessa. Toivomme, että käytätte noin puoli tuntia ajastanne kyselyyn vastaamiseen. Odotamme vastaustanne oheisessa kirjekuoressa, jonka postimaksun olemme maksaneet, **noin kolmen viikon sisällä.**

Tutkimus tehdään LIKES-tutkimuskeskuksen ja Jyväskylän yliopiston Liikuntakasvatuksen tutkimus- ja kehittämiskeskuksen yhteistyönä. Sitä rahoittavat Opetusministeriö ja Juho Vainion säätiö sekä Urheiluopistosäätiö. Antamianne tietoja käsitellään ehdottoman luottamuksellisina eikä yksityistä vastaajaa koskevia tietoja ilmoiteta missään vaiheessa. Lomakkeen yläreunassa oleva numero ilmoittaa henkilönumeronne vuoden 1976 mittauksessa ja se muutetaan aineistojen yhdistämisen jälkeen.

Osoitetiedot olemme saaneet Jyväskylän maistraatista.

Keväällä 2001 on osa vastaajista tarkoitus kutsua haastatteluun ja jatkomittauksiin. Niihin osallistuminen on luonnollisesti täysin vapaaehtoista. Korostamme, että vastaaminen tähän kyselyyn ei sido osallistumaan niihin. Tiedustelemme kyselyn lopussa, saammeko ottaa yhteyttä Teihin sopiaksemme näistä jatkomittauksista, jotka pidetään Liikuntakeskus Pajulahdessa (esite ohessa).

Lomaketta ja jatkomittauksia koskevat kysymykset voi esittää allekirjoittaneille Lasse Mikkelssonille tai Heimo Nupposelle, joilta saa myös tietoja vuonna 1976 tehdystä tutkimuksesta.

Veikko Vihko
Tutkimusjohtaja
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KYSELYLOMAKE
Kysymyksiin vastataan ympyröimällä jokaisessa kysymyksessä yksi vaihtoehto (numero) tai kirjoittamalla vastaus sitä varten varattuun tilaan

35 **Kuinka pitkä olette?**

_____ cm (senttimetrin tarkkuudella)

Kuinka paljon painatte?

_____ kg (kilon tarkkuudella)

37 **Mihin kunto-ominaisuuksien luokkaan arvioitte kuuluvanne nyt. Vertailuryhmänä ovat samanikäiset ja samaa sukupuolta olevat.**

	Selvästi alle keskitason	Alle keskitason	Keskitaso	Yli keskitason	Selvästi yli keskitason
Kestävyys	1	2	3	4	5
Nopeus	1	2	3	4	5
Voima	1	2	3	4	5
Notkeus	1	2	3	4	5

38 **Kuinka usein harrastatte liikuntaa? Merkitkää rasti alla olevaan ruudukkoon rasti siihen kohtaan, joka vastaa tilannetta normaaliviikkona.**

En lainkaan, siirtykää kysymykseen 45	1
Kerran kuukaudessa	2
2-3 kertaa kuukaudessa	3
1-2 kertaa viikossa	4
3-4 kertaa viikossa	5
5-6 kertaa viikossa	6
Joka päivä	7

39 **Kuinka kauan yleensä harrastatte liikuntaa yhdellä kerralla?**

Alle 10 minuuttia	1
10-20 minuuttia	2
20-40 minuuttia	3
40-60 minuuttia	4
60-90 minuuttia	5
1.5 tuntia tai enemmän	6

40

Mitä liikunnan muotoja tai lajeja harrastatte ja millä teholla ?

	En harrasta	Harrastaessani en sanottavasti hengästy	Hengästyn jonkin verran	Hengästyn voimakkaasti
Kävely	1	2	3	4
Hölkkä	1	2	3	4
Juoksu	1	2	3	4
Voimistelu	1	2	3	4
Tanssi	1	2	3	4
Kuntosaliharjoittelu	1	2	3	4
Laskettelu	1	2	3	4
Maastohiihto	1	2	3	4
Suunnistus, retkeily	1	2	3	4
Luistelu, rullaluistelu	1	2	3	4
Uinti	1	2	3	4
Soutu, melonta	1	2	3	4
Jalkapallo	1	2	3	4
Koripallo	1	2	3	4
Lentopallo	1	2	3	4
Pesäpallo	1	2	3	4
Jääkiekko, kaukalopallo	1	2	3	4
Sulkapallo	1	2	3	4
Squash, tennis	1	2	3	4
Golf	1	2	3	4
Aerobic	1	2	3	4
Sauvakävely	1	2	3	4
Muu, mikä_____	1	2	3	4
	1	2	3	4

41 **Kuinka usein osallistutte voimistelu- tai urheiluseuran harjoituksiin tai muuhun ohjattuun liikuntaan?**

En ollenkaan	1	siirtykää kysymykseen 44
Kerran kuukaudessa	2	
2-3 kertaa kuukaudessa	3	
1-2 kertaa viikossa	4	
3-4 kertaa viikossa	5	
5-6 kertaa viikossa	6	
Joka päivä	7	

42 **Jos osallistutte ohjattuihin harjoituksiin niin millä teholla liikutte?**

	Teho
En sanottavasti hengästy	1
Hengästyn jonkin verran	2
Hengästyn voimakkaasti	3

43 **Jos osallistutte kilpaurheiluun niin mikä on lajinne ja tasonne ?**

Lajini on _____ ja kilpailen

puulaaki	1	
seura	2	
piiri	3	
kansallisella	4	
kansainvälisellä	5	tasolla

49 **Mihin seuraavista suorituksista arvioitte pystyvänne vaihtelevassa maastossa:**

yhtämittaiseen juoksuun	alle 500 m 1	500-1000 m 2	1–5 km 3	yli 5 km 4
yhtämittaiseen pyöräilyyn	alle 10 km 1	10 – 20 km 2	21-50 km 3	yli 50 km 4
yhtämittaiseen hiihtoon	alle 5 km 1	5 – 10 km 2	11-30 km 3	yli 30 km 4
yhtämittaiseen patikointiin	alle 5 km 1	5 – 10 km 2	11-20 km 3	yli 20 km 4

50 **Kuinka pitkän matkan arvioitte pystyvänne uimaan yhtämittaisesti?**

en osaa uida 1	alle 20 m 2	20-200 m 3	yli 201-500 m 4	yli 500 m 5

54 **Saammeko ottaa teihin yhteyttä koskien jatkomittauksia?**

1 kyllä
2 ei

MONET KIITOKSET AVUSTANNE!