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Diversity of leisure-time sport activities in adolescence as a predictor of leisure-time physical activity in adulthood

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Abstract

Because sustained physical activity is important for a healthy life, this paper examined whether a greater diversity of sport activities during adolescence predicts higher levels of leisure-time physical activity (LTPA) in adulthood.

From sport activity participation reported by 17-year-old twins, we formed five groups: 1, 2, 3, 4, and 5+ different sport activities. At follow-up in their mid-thirties, twins were divided into four activity classes based on LTPA, including active commuting. Multinomial regression analyses, adjusted for several confounders, were conducted separately for male (N=1288) and female (N=1770) participants. Further, conditional logistic regression analysis included 23 twin pairs discordant for both diversity of sport activities in adolescence and LTPA in adulthood.

The diversity of leisure-time sport activities in adolescence had a significant positive association with adulthood LTPA among females. Membership in the most active adult quartile, compared to the least active quartile, was predicted by participation in 2, 3, 4, and 5+ sport activities in adolescence with odds ratios: 1.52 (p=0.11), 1.86 (p=0.02), 1.29 (p=0.39), and 3.12 (p=5.4e-05), respectively. Within-pair analyses, limited by the small sample of twins discordant for both adolescent activities and adult outcomes, did not replicate the association.

A greater diversity of leisure-time sport activities in adolescence predicts higher levels of LTPA in adulthood in females, but the causal nature of this association remains unresolved.

Keywords

youth; exercise; longitudinal; cohort study; twin study; behavioural epidemiology

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Introduction

Regular physical activity (PA) is associated with a healthy and independent life as PA plays an important role in preventing many non-communicable diseases (Seefeldt et al., 2002, Bull & Bauman, 2011). However, only two-thirds of adults worldwide attain the minimum level for health-enhancing PA (Hallal et al., 2012). Even fewer adults achieve the weekly recommended levels of diverse PA—aerobic exercise for 150 minutes at moderate intensity or 75 minutes at vigorous intensity or a combination, along with muscle strengthening and balance/agility/flexibility-improving activities at least twice a week (World Health Organization 2010). Among 15- to 64-year-old Finns, only 11% reached those WHO recommended levels of diverse PA, including both aerobic and muscle strengthening activity (Helakorpi et al., 2010). Among U.S. adults, this proportion is around 16% (Schoenborn & Stommel, 2011).

Regular PA is essential for acquiring the health benefits of reduced cardiovascular disease risk and mental distress (Rangul et al., 2012). Accordingly, most longitudinal studies have concentrated on the stability of PA tracking: the maintenance of a person's relative rank or position within an activity group over time (Malina, 2001). PA level correlations between time points range from low to moderate and tend to decrease as time increases (Telama, 2009). A dramatic decline in PA level during adolescence and the transition to adulthood is evident (Dumith et al., 2011). Based on a review by Dumith et al. (2011), the steepest period of decline among males happens around 13–16 years old and somewhat earlier among females, around 9–12 years old. This erosion of PA levels between sexes seems to continue into young adulthood (ages 18–29), but somewhat stabilises in middle adulthood (ages 30–64) (Caspersen et al., 2000). A marked decline is seen in regular participation in vigorous-intensity activities in the transition to adulthood, especially in males who tend to report higher PA levels and participate in significantly more vigorous activities in adolescence than their female peers (Caspersen et al., 2000, Hallal et al., 2012, Sallis et al., 1996). Part of these changes in PA levels may be due to genetic factors that significantly influence individual differences in PA traits, with heritability estimates of leisure-time exercise behaviour strongly varying over age, ranging from 27% to 84% (de Geus et al., 2014). At the same time, the twin studies reviewed by de Geus et al. (2014) indicate the influence of person-specific environment increasing from late adolescence to middle age.

In an effort to explore the individual, environmental factors affecting the decline in PA during adolescence and the transition to adulthood, several studies have related the decline to a simultaneous decline in participating in a number of different sport activities (Aarnio et al., 2002, Aaron et al., 2002, Dovey et al., 1998). A recent study by Jose et al. (2011) revealed that participation in three or more sport activities in childhood/adolescence had a statistically sifgnificant association with persistent PA during the transition from adolescence to adulthood. In contrast, another study found that diverse sports participation (3 or more different sport activities) in adolescence predicted higher active commuting in adulthood, but had no association with adult leisure-time physical activity (LTPA) (Cleland et al., 2012). In a retrospective questionnaire study among female students at a Canadian university, the women who were considered active at age 18 reported a significantly greater number of physical activities between the ages of 6 and 18 than their inactive peers (Robertson-Wilson et al., 2003). Furthermore, findings from a Norwegian study showed that, in general, concurrent participation in several sport activities during adolescence is moderately associated with the level of LTPA in later life (Kjonniksen et al., 2008).

Early sampling—a term used by Côté & Vierimaa (2014), describing diversity of sport activities participated in during childhood — is supported by the Developmental Model of Sport Participation (DMSP). The model was conceptualised 17 years ago and consists of postulates, most of which focus on the influence of sampling and deliberate play on a youth’s participation, performance, and personal development in sport. Evidence derived through the years provides a strong recommendation for sport programs to encourage early involvement in different sports and contexts to promote the development of long-term participation in sport (Côté & Vierimaa, 2014). Additionally, motor skills acquired in childhood and early adolescence have shown a positive association with self-reported LTPA levels in adulthood (Aaltonen et al., 2015). A Finnish longitudinal study on the effect of different types of sport activities also demonstrated that participation in both intensive endurance sports and sport activities that improve motor skills via various methods is associated with higher levels of PA in later life (Tammelin et al., 2003b).

In summary, some evidence suggests that participation in several sport activities during adolescence refines motor skills and promotes the maintenance of higher levels of LTPA later in life. The aim of this longitudinal study was to investigate whether a greater diversity of sport activities in adolescence is associated with higher levels of LTPA in adulthood. Both the quantity and quality of sport activities were considered. Our use of twin data provides a unique opportunity to control for potential shared genetic and environmental influences affecting the association. The study period, from the age of 17 to mid-thirties, covers several potential major life events (such as the transition to university, starting work, getting married, or having a child), which have been associated with decreased PA (Engberg et al., 2012).

Materials and methods

Sample

The study sample consisted of Finnish twins born in 1975–79 enrolled in the FinnTwin16 project, which is a nationwide longitudinal cohort study of the health behaviours of twins and their families (Kaprio et al. 2002). The Central Population Register provided information on twin pairs and the first contact took place between 1991 and 1995, the month after the twins reached the age of 16. In the first survey, the pairwise response rate was 88%. The second, third, fourth, and fifth wave took place when the twins were aged around 17 (mean 17.1, range 17.0–18.0), 18 (18.6, 18.3–19.4), 24 (24.5, 21.0–28.6), and 34 (34.1, 31.9–37.4). The latest survey wave was a web-based questionnaire conducted between 2010 and 2012 with a response rate of 72%. The Ethics Committee of the Hospital District of Helsinki and Uusimaa and the Institutional Review Board of Indiana University, Bloomington, USA provided permission to conduct the study. All twins (or their parents) gave informed consent at all waves of the FinnTwin16 project.

In this study, we utilised data from the first, second, and fifth waves of the FinnTwin16 project. Our main analysis based on data from the second and fifth waves in which twins participating in both waves numbered 3860 (42.9% male) (Figure 1). First, we included only twins who had provided information on physical activity related variables (N=3651). Second, we excluded those with chronic diseases or disability (N=409) based on a question in the first and fifth waves: "Do you have any long term illness or disability which hinders your daily activities?" We excluded those who reported having a medical condition that could prevent participation in LTPA, such as motor disabilities, chronic diseases, and some mental disorders (depression, schizophrenia, etc.) (Aaltonen et al., 2013). Furthermore, in the analyses we included only twins who had provided information on all confounders.

Assessment of physical activity

The second wave questionnaire (mean age 17.1 years) provided information about the adolescents' general LTPA behaviour. Our focus was on questions related to LTPA frequency and the diversity of sport activities participated in (other than school sports, as they were not surveyed in the questionnaire). The latter was collected with a multiple-choice question consisting of 18 different sport activities and an open field question (Supplementary file 1). Based on LTPA frequencies, the twins were divided into two categories: inactive (LTPA less than once a month) or active (LTPA at least once a month). We then further divided active twins, based on their pooled number of sport activities participated in, into five groups: 1, 2, 3, 4, and 5 or more sport activities. We also formed four subcategories based on the type of sport activity: endurance (e.g. walking, running, swimming, skiing), power (gym, weight lifting, body building), games (e.g. ball and racket games), and others (e.g. dance, martial arts, motor sports) (Supplementary table 2). This sub-categorisation was created to depict the different nature of sport activities in order to explore whether a specific participation pattern results in more LTPA in adulthood.

LTPA levels in adulthood (mean age 34.1 years) were assessed as leisure-time Metabolic Equivalent of Task (ltMET-h/day). The ltMET indices were calculated based on structured questions of LTPA (Supplementary file 1). Twins reported their monthly/weekly LTPA frequency, mean duration, mean intensity of LTPA sessions, and PA during journeys to and from work (active commuting). Each reported intensity was assigned a multiple of the resting metabolic rate (MET score) as follows: 4 (for exercise intensity corresponding to walking), 6 (interval walking and jogging), 8.3 (jogging), and 11 (running)(Ainsworth, Haskell et al. 2011). A MET value of 4 was assigned for the intensity of active commuting (usually walking). Finally, the ltMET indices (ltMET-h/day) were calculated as follows: (LTPA frequency×mean duration×mean intensity) + (active commuting frequency [assumed 5 days/week]×mean duration×intensity).

The formulated created ltMET index had a skewed distribution (skewness value of 1.63). Thus, we tried several transformations (including logarithmic and square root transformations) to reach a normally distributed variable, but none provided an adequate fit to represent our data. Accordingly, we chose a statistical approach to divide the participants into activity quartiles, creating categories with an almost equal number of participants, which permitted evaluation of class-specific effects. For males, the quartile cut points were

1.53, 3.78, and 5.83 ltMET-h/day; for females, they were 1.49, 2.99, and 5.28 ltMET-h/day, respectively. The cut points for the lowest ltMET-quartile were then close to the WHO recommendation for weekly PA (equal to 1.5 MET-h/day) (World Health Organization, 2010). In the final analyses, we compared only the least and the most active quartiles.

Confounding factors

The full statistical model contained commonly known correlates and confounders for PA: health status, education, type of work, smoking, having children, and being pregnant (females only) at follow-up at the age of 34 (Bauman et al., 2012). In the follow-up, twins reported their health status by choosing one of the following options: poor, rather poor, mediocre, good, or very good. The level of education had six classes based on the highest educational degree achieved: junior high school, vocational school, college level, senior high school, university of applied sciences, or university. Categories for the work activity level were: light (sedentary/some walking), heavy (frequent walking/lifting/digging etc.), and not working/studying at the moment.

We also adjusted the analyses for the frequency of sport participation in adolescence based on the question: “How often do you exercise or do sports during your leisure time?” Options were: not at all, less than once a month, 1–2 times a month, about once a week, 2–3 times a week, 4–5 times a week, just about every day. Participants who were active less than once a month were considered inactive. Based on the responses, we calculated the mean frequency of sport participation per week and used it as a continuous variable in the analysis to evaluate its overall effect. We also tested whether alcohol use in adolescence or in adulthood could have a confounding effect, but due to its low correlation with the main variables in our study, alcohol use was not included as a potential confounder.

Thus, we considered adolescent PA level, adult health status, and education as regular scale variables, but we used them as continuous variables to explore trend effects. Work activity level, however, was used as a categorical variable to detect differences between sedentary and heavy physical work. In addition, we treated some potential adult confounding factors as dichotomous variables: smoking (ever/never), having children (yes/no), and currently pregnant at follow-up (yes/no, females only). Participants with missing information on confounders were excluded from the analyses.

Finally, in aim to examine potential shared genetic and environmental influences affecting the association, we identified twin pairs (N=54) discordant for their diversity of LTPA (number of leisure-time sports participated in) during adolescence as pairs in which one twin engaged in several sport activities while their co-twin engaged in only one (inactive twins were excluded). Of the 54 twin pairs identified as baseline-discordant, only 23 (4 monozygotic pairs and 19 dizygotic pairs) were also outcome-discordant: one twin in the most active quartile and their co-twin in the least active quartile. Out of the 23 double-discordant twin pairs, seven were twin brothers, five were twin sisters, and 11 brother-sister twin pairs.

Statistical methods

We performed analyses using the Stata statistical package, version 13.1 (Stata corp, 2013). We examined variable distributions and normality by computational and visual means. Both of our main variables appeared to have skewed distributions: the number of sport activities had a skewness value of 1.26 and the ltMET index a skewness value of 1.63. Thus, we considered several different regression models and normality transformations for the variables before choosing multinomial regression analysis as the best statistical approach for our data. When making the categorisations for the main variables, we aimed to keep the number of categories informative and reasonable and the number of study participants effectively equal between categories in order to maximise statistical power. The level of significance was set at $p<0.05$.

In the primary analyses, we considered the twins as individuals. In the multinomial logistic regression analysis, we used the number of different sport activities participated in during adolescence as a categorical variable to predict adulthood membership in the activity quartiles. Inactive adolescents were excluded from this analysis. Due to known differences in LTPA patterns, we conducted models separately for male (N=1288) and female (N=1770) participants. When we analyzed the twins as individuals, we controlled for the clustering of correlated observations using robust estimators of variance (Williams, 2000). Separate models also assessed the type of sport activity participation with the subcategories: endurance, power, games, and others. We calculated mean ltMETs and standard deviations (SD) for all possible subcategory combinations, including the inactive adolescents, and detected the sport activity profile resulting in the most active adults.

Conditional logistic regression utilising twin pairs discordant for adolescent activity provided a tool to evaluate possible additional confounding due to familial factors (such as family environment or genes) common to the co-twins. In terms of ltMET values, we chose to include only the extreme categories of the distribution—the least and most active quartiles—in the final analysis. First, we performed conditional logistic regression (Thomas 2004) on 23 baseline- and outcome-discordant twin pairs (4 monozygotic pairs and 19 dizygotic pairs) and adjusted the analyses for sex. Then, we conducted analyses separately for same-sex twin pairs (7 twin brothers and 5 twin sisters).

Results

The weekly mean frequencies of leisure-time sport activity participation were somewhat higher for boys (3.20, SD 2.43) than girls (2.77, SD 2.17) in adolescence. However, the mean number of sport activities participated in were similar for boys (3.30, SD 2.25) and girls (3.27, SD 1.98) at age of 17. Of note, however, is that, on average, girls engage in a greater number of different sport activities to acheive their weekly PA hours. Study sample characteristics show an increase in the mean number of sport activities participated in during adolescence (2.93, 3.25, 3.35, and 3.58) moving from the lowest to the highest LTPA quartiles in adulthood. Independent of sex, a higher proportion of twins in the more active ltMET quartiles were healthy, had higher education levels, and had more sedentary/light activity work environments. Adult twins in the lowest ltMET quartile, however, were more likely to have ever smoked, to have children, or, among females, to currently be pregnant (Table 1).

For the multinomial logistic regression analysis of the diversity of leisure-time sport activities, we used participants engaging in only one sport activity during adolescence as the reference group. Concerning LTPA in adulthood, the results in Table 2 include odds ratios (OR) for only the lowest and highest ltMET-quartiles (Figure 2). For female participants, the number of sport activities in adolescence (2, 3, 4, and 5+) predicted membership in the most active LTPA quartile in adulthood compared to the least active quartile with the following ORs (95% confidence intervals [CI]) from the full model: OR 1.52 (95% CI 0.91–2.55), 1.86 (1.11–3.14), 1.29 (0.73–2.28) and 3.12 (1.79–5.42), respectively. For male participants, corresponding estimates were 1.05 (0.63–1.75), 0.72 (0.42–1.24), 0.70 (0.40–1.22), and 1.14 (0.68–1.90), respectively. Complete results (i.e. including all ltMET-quartiles) are available in supplemental tables 2 and 3.

In adulthood, the mean ltMET values for males and females were 4.36 (SD 3.56) and 3.96 (SD 3.44) MET-h/day, respectively. Participants who in adolescence reported being active in all four subcategories (endurance, power, games, and others) or in just the first three (endurance, power, and games) had the highest mean ltMET values in their mid-thirties, i.e. 5.18 MET-h/day and 5.05 MET-h/day for males, respectively, and 4.95 MET-h/day and 5.14 MET-h/day for females, respectively. Females who had no participation in endurance activities in adolescence had lower ltMET values in their mid-thirties (Table 3). Among males, no similar category-specific trends were detected.

The cross tabulation of outcomes in the extreme LTPA quartiles (lowest vs highest) in adulthood for baseline discordant twin pairs (N=54) illustrates that twins tend to become similarly active over time (Table 4). Most of the baseline discordant twin pairs were concordant for the least active quartile in adulthood (N=20). In the conditional logistic regression analysis (without confounders), intra-pair differences in the diversity of adolescent sport activities were not associated with discordance in adulthood LTPA. Thus, we were unable to replicate the results of the individual-based multinomial logistic regression. For all double-discordant twin pairs (N=23), ORs (95% CI) were 1.28 (0.54–3.05), 3.00 (0.31–28.84) for monozygotic pairs (N=4) and 1.07 (0.41–2.79) for dizygotic pairs (N=19) (results not shown). Results collapsed on sex were OR 2.50 (0.49–12.89) for male-male pairs (N=7) and 0.25 (0.03–2.24) for female-female pairs (N=5).

Discussion

This longitudinal study showed a positive association between the number of leisure-time sport activities participated in during adolescence and LTPA in adulthood among females only. For males, no significant association was found. However, diversity in the quality of sport activities participated in, in terms of subcategory combinations (endurance, power, games, and others), seemed to result in more physically active adults for both sexes. Based on the unique nature of our twin study sample, we were able to explore the causal nature of these initial results using conditional logistic regression analysis of discordant twin pairs. However, the final sample for analysis was small due to the extremely rare situation of double-discordant twin pairs, and thus the statistical power of our discordant twin comparisons was limited. The results suggest, however, that the longitudinal association between diversity of sport activities in adolescence and adulthood LTPA may, at least partly, be attributed to common familial factors, including shared environment and genetic factors. Clarification of the results require a larger discordant sample.

Our findings of sex differences in the association between the diversity of leisure-time sport activities in adolescence and LTPA in adulthood is in line with those obtained by previous studies (Kjonniksen et al., 2008) suggesting stronger associations among females. Previous studies have suggested multiple factors that may explain these sex differences. Males tend to maintain their level of PA better than females, indicating the relevance of participation frequency (Telama, 2009). Additionally, men are more likely to engage in vigorous activities than women (Caspersen et al. 2000, Hallal et al., 2012, Sallis et al., 1996). However, time spent in vigorous activities is the form of PA that declines most during the transition into adulthood (Caspersen et al. 2000, Hallal et al., 2012, Sallis et al., 1996). Another difference between the genders is that adolescent boys prefer team sports whereas girls seem to engage in more individual activities (Aaron et al., 2002). In our study sample, girls engaged, on average, in a greater number of different sport activities to acheive their weekly PA hours. Thus, we might speculate that the male erosion of LTPA levels in adulthood may be due to more declined participation in vigorous and/or team sports. Whereas among women, the LTPA levels appear to be more stably bound to regular participation in different sport activities.

The transition from adolescence to adulthood is also known to include several life changes (transition to university, having a child) affecting PA in both genders. Additionally, some changes, such as beginning a job, change in work conditions, a change from being single to cohabiting, marriage, and pregnancy are associated with decreased LTPA, mostly in young women (Engberg, et al., 2012). Even though gender roles are becoming more equal, adulthood may still bring different role expectations for men and women — family responsibilities and child rearing may continue to be performed mainly by women. Perhaps women require broader and more diverse experience with sport activities in adolescence to be motivated to engage in regular PA in adulthood when work and family commitments may threaten their ability to be physically active.

Jose et al. (2011) and Aaron et al. (2002), however, found no sex differences in their results demonstrating that diverse sport participation in childhood/adolescence predicts persistent PA in young adulthood. Furthermore,Aaron et al. (2002) showed that beginning a new sport activity during the 4-year period from age 12 to age 15 is uncommon. Additionally, a previous study using our same Finntwin16 data showed a similar tendency; the greater the number of sport activities participated in at the age of 17, the higher the stability of LTPA across ages 16, 17, and 18 (Aarnio et al., 2002). These results may indicate the importance of maintaining diversified sport participation as a way to avoid the commonly observed decline in LTPA level. Participation in a greater number of sport activities likely also contributes to achieving the recommended levels of health-enhancing, diverse PA (World Health Organization 2010). Among 15- to 64-year-old Finns, 37% reached the recommended level for the aerobic but not for the muscle strengthening activity, and 31%

regurlarly participated LTPA but lacked the recommended intensity or frequency of LTPA (Helakorpi et al., 2010). Those results along with ours implicate the need to promote diverse sport participation, including muscle strenghtnening and aerobic activity with different intensities, from adolescence to adulthood.

The DMSP states, “Early diversification (sampling) is linked to a longer sport career and has positive implications for long-term sport involvement,” which is supported by accumulated high-quality evidence (Côté & Vierimaa, 2014). A study of 6–12 –year-old boys who either specialised in one sport or sampled a diverse number of sport activities showed that early diversification promoted prolonged long-term engagement in sport through the development of fundamental motor skills applicable for a range of sport activities (Fransen J et al., 2012). For example, running has been considered as an easily transferable skill between different sport activities (Sallis et al., 1996), and a recent study reported that the number of years participating in running during adolescence relates to higher adult PA (Belanger et al., 2015). Additionally,Tammelin et al. (2003) highlighted the importance of exposure to sport activities requiring and encouraging diversified sport skills early in childhood as it leads to later use of these skills and has a positive association with later LTPA.

Several studies referenced in the DMSP suggest a strong association between early specialisation and increased sport attrition (Côté & Vierimaa, 2014). One of the most common reasons to discontinue sport participation is injuries (Aaron et al., 2002), and a leading cause of injuries in young athletes is overstress of muscles and tendons or overuse of joints (Brenner & American Academy of Pediatrics Council on Sports Medicine and Fitness, 2007). In addition to physical overstress and overuse, there are also suggestions that psychological burnout and overtraining due to early specialisation may result in decreased performance and can cause drop-out from sports (Myer et al., 2016., Brenner & American Academy of Pediatrics Council on Sports Medicine and Fitness, 2007). Thus, the American Academy of Pediatrics (2007) recommends participation in a single sport activity no more than 5 days per week and advises the use of a variety of exercise modalities to reduce the overstress on body parts. One option for avoiding such overstress, overuse, and burnout is multisport participation that could help to achieve lifelong fitness and enjoyment of sport.

Our initial study sample was both large and representative of the general Finnish population. In our subsample of active twins, we had more female (N=1770) than male (N=1288) participants. Due to known PA behaviour differences between the sexes (Dovey et al., 1998, Aarnio et al., 2002, Telama, 2009), we conducted separate analyses by sex. Because twins tend to be born prematurely and, thus, may have lower birthweight, their PA may be expected to differ from singletons since low birthweight has been associated with low levels of PA (Andersen et al., 2009). However, the causes of low birthweight in twins are more physiological (i.e. lack of space *in utero* during the latter part of pregnancy) than in singletons (often due to placental or fetal disturbances). In adulthood, 74.5% of males and 74.2% of females in our study sample achieved the 2010 WHO guidelines for PA, which is somewhat higher than the global average (Hallal et al., 2012). Additionally, a previous study by Aarnio et al. (1997) showed that our individual twins’ PA patterns in adolescence are similar compared to singletons.

Our data provided valuable information on active commuting in adulthood and several known confounders included in the analyses. Internationally, the Finnish adult population has a relatively high rate of active commuting, around 20%, making it a considerable part of LTPA behaviour (Hallal et al., 2012). Recent evidence also suggests that maintaining or increasing active commuting from adolescence to adulthood is positively associated with overall PA (Yang et al., 2013). In our longitudinal study, maintenance of active commuting might explain some of our results in the qualitative subcategory analysis. Adolescent females not participating in endurance sport activities (walking, cycling, running, etc.) in their leisure time had no established active commuting habits to continue with in adulthood and perhaps then had lower mean ltMET values. Moreover, key strengths of the present study were a longitudinal study design, and exclusion of participants with chronic diseases.

One of the potential limitations of our study is that the questionnaire data may be vulnerable to recall bias (Sallis & Saelens, 2000). However, evidence shows the LTPA items of interest have a high correlation with interview-based LTPA data (Waller et al., 2008). Also, it should be noted that the potential for recall bias was small in our study design, as diversity of PA was assessed at the age of 17 —it was not reported retrospectively. PA surveys in general have a prominent role in the monitoring and understanding of PA patterns and the influences of behaviour. In an epidemiologic setting, using MET values as a standard, despite the criticism they have received, renders results between studies more comparable (Ainsworth et al., 2011).

Unfortunately, our PA questionnaire for adolescent twins provided no data on sport activity-specific frequencies, maintenance of participation, or sport activities tried at school, which would have helped to create a more complete picture of PA diversity. The number of different sport activities participated in during adolescence had an asymmetrical distribution in both sexes. In addition, the ltMET value in adulthood was not normally distributed and, lacking a suitable transformation, we did not use it as a continuous variable. Therefore, we created categorised variables and used multinomial regression analysis. In comparison with the WHO recommendation for weekly PA (equal to 1.5 MET-h/day), we found that our cut points for the lowest ltMET-quartile were almost equal (1.53 ltMET-h/day for males and 1.49 MET-h/day for females). However, such categorisation, may have constrained the statistical power to detect associations.

To conclude, as far as we know, this study is the first one to examine the effects of LTPA diversity within a longitudinal twin study design. In the individual-based analyses, we found that a greater number of leisure-time sport activities seems to enhance later LTPA levels, but only among females. We were, however, unable to replicate this association in comparisons of activity-discordant twin pairs, which by definition suggests the explored association may not be causal but may be affected also by shared genetic and/or environmental influences. Both the diversity of sport activities in adolescence and LTPA in adulthood are complex traits. Previous studies have shown high heritability estimates for various phenotypes of leisure-time exercise behaviour (de Geus et al, 2014). Furthermore, the associations between these complex traits may share some underlying genetic/environmental factors. However, the statistical power in our discordant sample was limited and more research is required to understand the factors underlying the association of diversified sport activity in adolescence and LTPA in adulthood.

Prospectives

Our results indicate the importance of diversified PA patterns in adolescence for LTPA behaviour in adulthood, especially among females. Adolescents, particularly girls, should be encouraged to participate in a variety of sport activities and to develop their motor skills to achieve ease and enjoyment during exercise, which can promote higher LTPA levels later in life (Aaltonen et al., 2015). Many researchers in the field endorse the statement that in adolescence one can still modify establishing habits, which may continue across the lifespan (Aaron et al., 2002, Tammelin et al., 2003).

Physical education lessons at school have an ideal position, reaching almost all adolescents and offering a low-cost approach to encourage different sport activities. Adolescents and young adults could also benefit from free community trials of sport activities as an optional and easy method to try something new. Sport clubs should be encouraged to offer non-competitive and inexpensive opportunities, since activities that are too high-level or expensive could be reasons to quit or not attempt the activity at all. The diversity of adolescent sports participated in can also help to avoid injuries and protect youth against neck, shoulder, and lower back pains (Auvinen et al., 2008) which are a growing public health issue.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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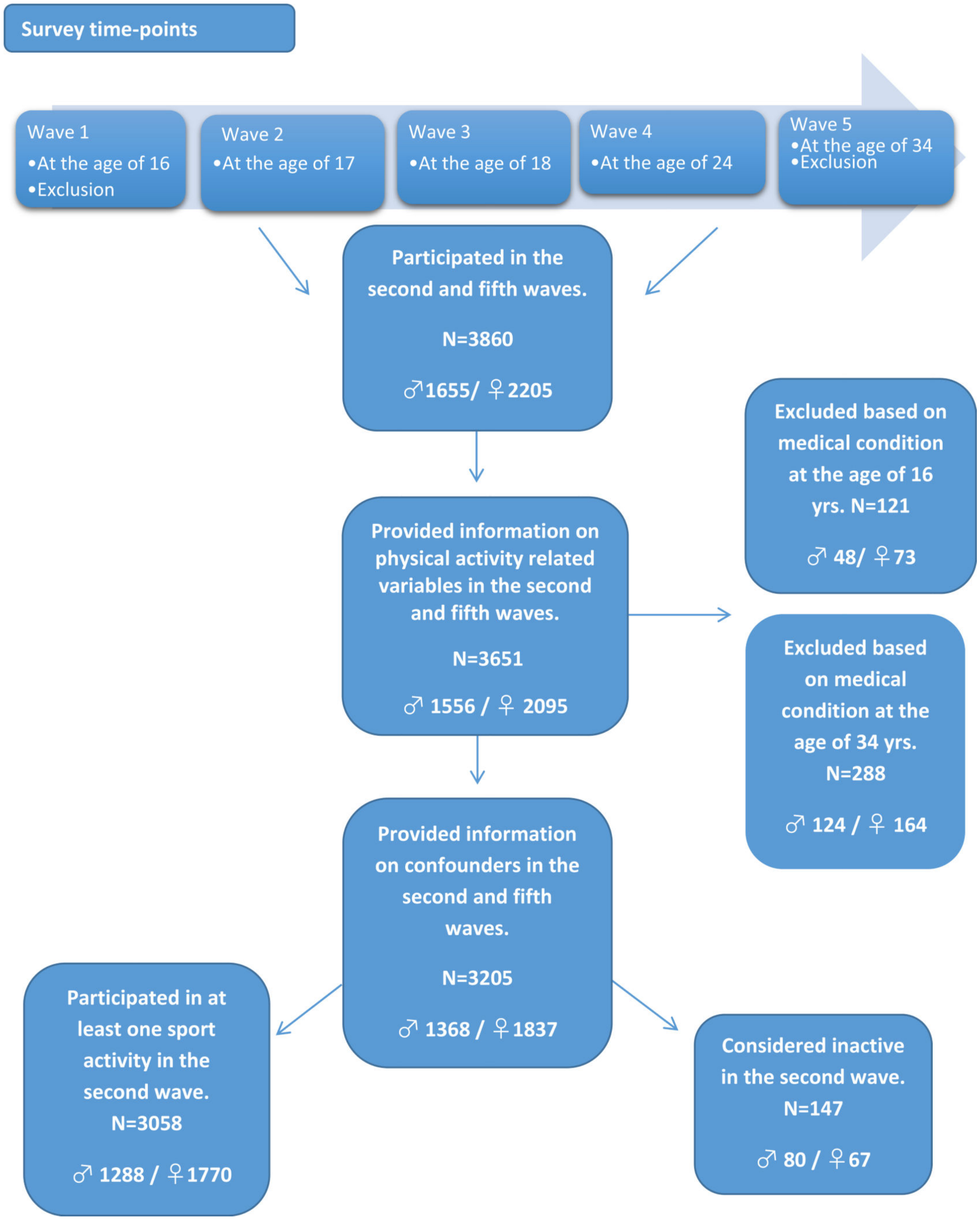

Figure 1. Formation of the study sample

Survey timepoints of the FinnTwin16 project and formation of the study sample showing the inclusion criteria and excluded individuals.

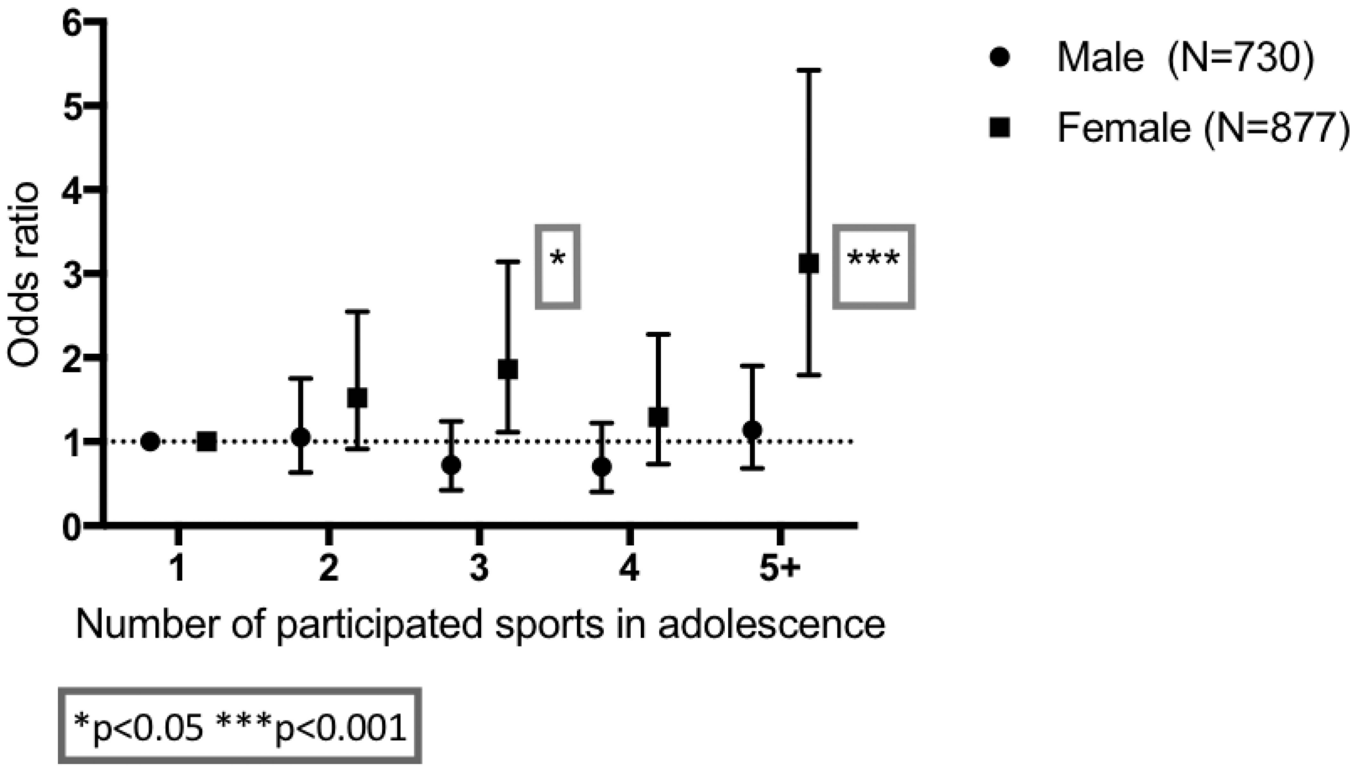

Figure 2.

Membership in the most active vs. the least active quartile in adulthood (based on Full model results presented in Table 2)

Table 1

Characteristics of the study participants (N=3205)

		ltMET quartiles at the age of 34			
		1 (Lowest)	**2**	**3**	**4 (Highest)**
Sex, column % (N)	Male (1368)	44.1 (360)	42.7 (335)	35.0 (256)	47.8 (417)
	Female (1837)	55.8 (456)	57.3 (450)	65.0 (476)	52.2 (455)
BASELINE* CHARACTERISTICS (mean±SD)					
Number of sport activities		2.93±1.96	3.25±2.03	3.35±2.09	3.58±2.24
Frequency of exercise: times a week		2.33±2.10	2.79±2.21	3.03±2.36	3.64±2.36
FOLLOW-UP CHARACTERISTICS, % in ltMET quartiles (N)**					
Health status: very or quite good		74.9 (609)	84.3 (662)	90.6 (663)	93.8 (818)
Highest education level: College level or higher		70.7 (577)	76.8 (603)	78.7 (577)	77.2 (674)
Work activity level: sedentary/light		58.6 (478)	67.5 (530)	65.4 (479)	68.4 (596)
Has children		72.9 (595)	64.6 (507)	60.1 (440)	55.5 (484)
Smoking (ever)		52.4 (428)	48.0 (377)	45.0 (329)	43.1 (376)
Currently pregnant (female only)		12.7 (58)	8.89 (40)	7.14 (34)	5.93 (27)

* At the age of 17

** At the age of 34

Table 2

Multinomial regression analysis results, membership in the most active vs. least active quartile

	Basic* model						**Full** model**					
	Male (N=730)			**Female (N=877)**			**Male (N=730)**			**Female (N=877)**		
Number of sport activities participated in during adolescence	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
1	1.00			1.00			1.00			1.00		
2	1.09	0.68–1.78	0.708	1.57	0.98–2.52	0.058	1.05	0.63–1.75	0.852	1.52	0.91–2.55	0.110
3	0.85	0.51–1.39	0.510	1.84	1.15–2.96	0.012	0.72	0.42–1.24	0.233	1.86	1.11–3.14	0.019
4	0.94	0.56–1.57	0.815	1.62	0.96–2.76	0.073	0.70	0.40–1.22	0.204	1.29	0.73–2.28	0.386
5 or more	1.71	1.08–2.70	0.022	3.95	2.41–6.46	4.9e-08	1.14	0.68–1.90	0.680	3.12	1.79–5.42	5.4e-05

OR=Odds ratio, CI= Confidence Intervals

* Basic model adjusted for age

** Full model adjusted for several confounders

Table 3

Participation in different types of sport activities in adolescence and mean leisure-time MET-values in adulthood.

				Male			Female		
				Mean ltMET-h/day	**SD**	**N**	**Mean ltMET-h/day**	**SD**	**N**
				4.25	**3.56**	**1368**	**3.86**	**3.43**	**1837**
Participation in different combinations of sport activities									
Endurance	Power	Games	Others						
+	+	+	+	5.18	3.94	119	4.95	4.32	160
+	+	+	−	5.05	4.11	121	5.14	4.06	35
+	+	−	+	4.69	3.94	48	4.49	3.61	265
+	−	+	+	4.42	3.84	131	3.98	3.33	207
−	+	+	+	4.93	3.46	34	3.25	2.89	20
+	+	−	−	3.93	2.56	58	4.74	3.65	40
+	−	+	−	4.47	3.65	190	3.74	3.54	142
+	−	−	+	3.60	2.90	59	3.93	3.32	350
−	+	+	−	4.31	3.77	94	3.82	3.01	7
−	+	−	+	4.96	3.36	20	3.11	3.18	34
−	−	+	+	4.16	3.16	71	3.69	3.74	28
+	−	−	−	3.68	3.07	121	3.41	3.11	353
−	+	−	−	3.74	3.27	19	4.23	3.40	5
−	−	+	−	4.46	3.24	136	3.49	2.35	29
−	−	−	+	4.81	3.96	47	3.44	2.92	95
−	−	−	−	2.93	2.72	80	3.59	2.73	67

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Table 4

Outcomes of the baseline discordant twin pairs

		Twin participating in several sports during adolescence	
Twin participating in only one sport during adolescence		Lowest MET quartile	Highest MET quartile
	Lowest MET quartile	(20) *	14
	Highest MET quartile	9	(11) *

* Baseline discordant but outcome concordant twin pairs (not included in conditional logistic regression analysis)